Ornamental Horticulture in India

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Ornamental Horticulture in India

Commemorative Volume Released on the Eightieth Birthday of Dr B.P. Pal

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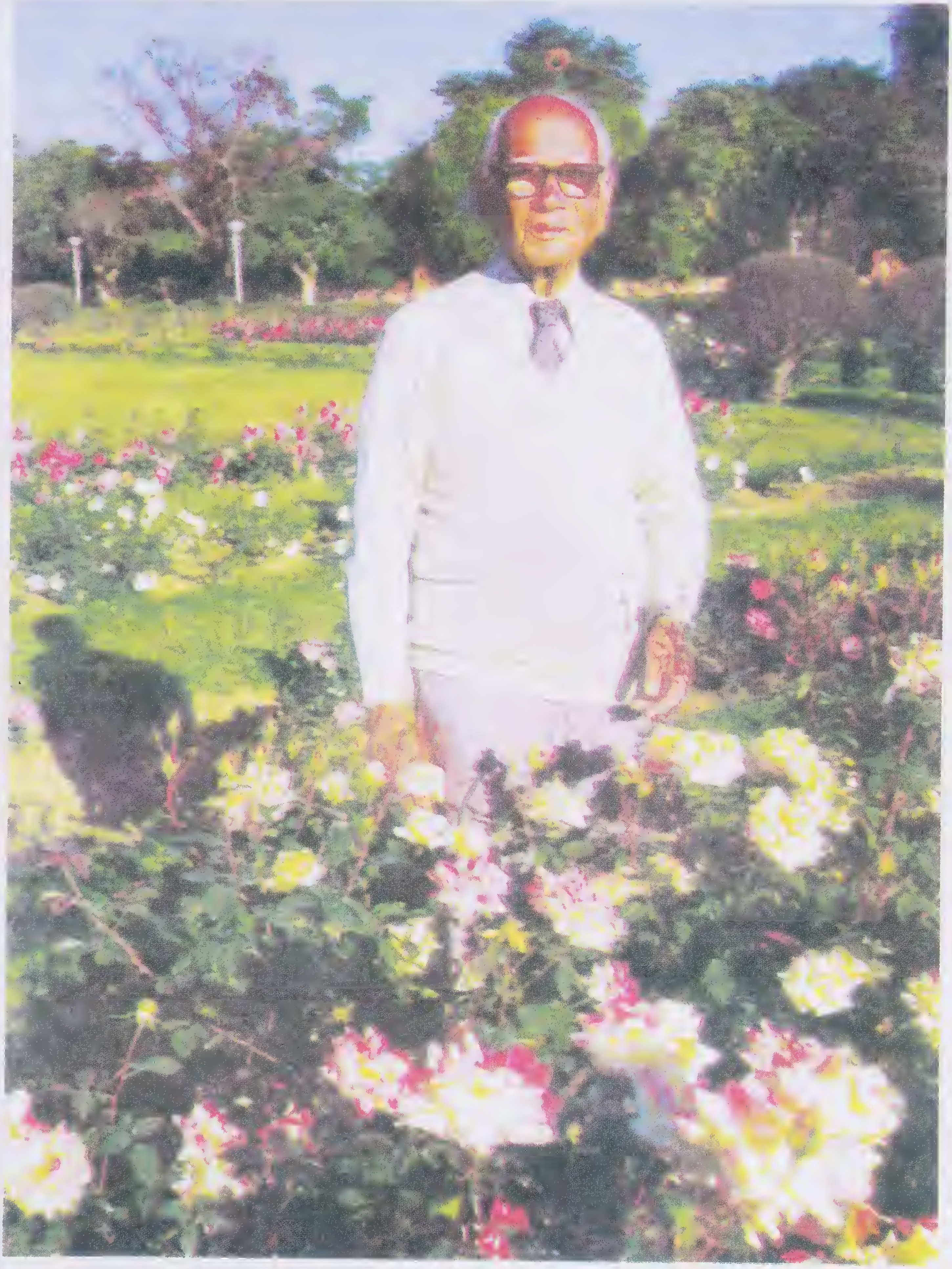

DR B.P. Pal

Foreword

ORNAMENTAL Horticulture is of great antiquity. Eloquent references to the aesthetics of ornamental plants, particularly flowers occur in our scriptures as also in the works of Kalidasa and other ancient poets. Ornamental plants also found patronage of Moghul emperors and some of the gardens established by them are still unparalleled in their design. In fact, Lutyen modelled the famous Moghul Gardens of the Rashtrapati Bhavan on the pattern of the gardens established by the Moghul emperors. The Vrindavan Gardens of the erstwhile princely State of Mysore (now Karnataka) is also a treat for the eyes.

Thanks to the diversity of climatic and soil conditions, the flora of our country is extremely rich, ranging from temperate to tropical flowering plants. In the earlier days, floriculture in India was more of an art than a science; however, with the increasing application of scientific techniques in the field of plant improvement, floriculture developed into a full-fledged scientific discipline. Scientists in the Botanical Survey of India made extensive collections of flowering plants and the Botanical Gardens at Calcutta is one of the monuments of these early efforts. Later on, many Indian botanists, particularly Dr B.P. Pal made significant contributions to floriculture. This subject is now included in the curriculum of many institutions of higher learning in the country and a large number of private firms are engaged in floriculture research and seed production. In fact, there exists immense potential in our country to export orchids, roses, gladioli and other distinctively Indian flowers.

Dr B.P. Pal has played a pioneering role in promoting ornamental horticulture in India. His active professional interest in floriculture is spread over almost four decades. Dr Pal has bred many varieties of roses and has been responsible for popularizing the art and science of floriculture through several societies. The ICAR is privileged to bring out this volume entitled 'Ornamental Horticulture in India' on the occasion of his 80th birthday. I hope the lovers of ornamental horticulture will find this topical publication informative and interesting.

It gives me great pleasure in complimenting the authors for their contributions to this volume at short notice. I am further grateful to the Technical Editors Dr K.L. Chadha and Dr B. Choudhury and ICAR Editors Shri P.L. Jaiswal and Dr (Mrs) A.M. Wadhwani and her team for editing and giving shape to this

publication and to Shri Krishan Kumar and his associates for bringing it out with a fine get-up in a very short time.

N.S. RANDHAWA
Director-General
Indian Council of Agricultural Research

19 May 1986
New Delhi

Preface

THE Horticulture Society of India decided to bring out a commemorative volume on the 80th birthday of Dr B.P. Pal. Keeping in view the contributions of Dr Pal to the cause of horticulture in India, particularly ornamental crops, it was felt that a volume on 'Ornamental Horticulture in India' would be most appropriate. Accordingly, all facets of ornamental horticulture were considered and articles on major commercial crops, their propagation, seed production, post-harvest technology, export and diverse aspects like bonsai plants, essential oils were invited by me. The ICAR also decided to bring out another volume on 'Growth and Development of Floriculture in India' simultaneously and requested Dr B. Choudhury to complete this volume. However, since the subject matter of both these volumes seemed identical, it was later decided to bring out only one volume on the subject. Thus the articles received by Dr Choudhury were also included in this publication.

The contributions of Dr Pal in the field of horticulture have been significant and are well known. Dr Pal paid a great deal of attention to floriculture which has been one of his principal hobbies. He has bred many varieties of roses including 'Dr Homi Bhabha', 'Raja of Nalagarh', 'Delhi Princess' and 'Banjaran'. He has also raised *Bougainvillea* varieties of which 'Dr R.R. Pal' is the most popular. He is known not only in India but also abroad as a rosarian and his book 'The Rose in India' has been very well received.

Dr Pal has been associated with several Horticulture Societies. He has been the President of Horticulture Society of India, Delhi Agri-Horticultural Society and Bougainvillea Society of India. He is also the President Emeritus of the Rose Society of India. Dr Pal is a Fellow of the Royal Horticulture Society of England and President of SATYA, the Delhi Chapter of the Friends of the Trees. It is, therefore, hoped that in bringing out this volume on the 80th birth anniversary of Dr Pal the subject of 'Ornamental Horticulture in India', which is so dear to his heart, will get its due importance.

It is my privilege to have been associated with the bringing out of this volume. It is hoped that the semblage of articles on various aspects of ornamental horticulture will provide useful information to the readers.

Thanks are due to the distinguished contributors who responded with

articles at a short notice and made it possible to bring out this commemorative volume. The authors also wish to record their thanks to Dr N.S. Randhawa, DG, ICAR, for kindly agreeing to bring out this volume at a very short notice.

K.L. CHADHA
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Government of India

15 May 1986
New Delhi

Contents

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Research on Ornamental Crops at the IIHR

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THE Indian Institute of Horticultural Research was established by the ICAR to conduct research on all aspects of horticultural crops, such as fruits, vegetables, ornamental, medicinal and aromatic crops, in order to improve their productivity, quality and utility. It was the first institute to establish a separate Division of Floriculture and Landscape Gardening in 1969. However, it was renamed the Division of Ornamental Crops in 1982.

Of the five well-defined laboratories, four deal with ornamental crop breeding—chrysanthemum, China aster and gladiolus; bougainvillea, roses, crotons and hibiscus; bulbous crops like *Hippeastrum*, dahlia and *Gloriosa*; and orchids and *Anthurium*. As such the research activities of the Division are mainly concentrated on the improvement of ornamental plants by selection, hybridization and mutation-breeding, and standardization of agro-techniques and rootstocks; with emphasis on ornamentals possessing export potential.

GERMPLASM COLLECTION

The germplasm collection, both from indigenous and exotic sources, consists of 425 varieties and 5 species of roses; 163 cultivars of chrysanthemum, 104 cultivars and 5 species of *Hibiscus*; 105 cultivars of *Bougainvillea*, 12 cultivars of China aster; 48 cultivars of *Hippeastrum*, 46 of gerbera, 4 of tuberose, 350 of croton and 185 species and 169 exotic hybrids of orchids. A large number of variety of shrubs, creepers and foliage plants have also been collected.

CROP IMPROVEMENT

Chrysanthemum

Germplasm of chrysanthemum was screened for growth and flower

characteristics. Twenty cultivars were found suitable for various purposes. 'Indira', 'Pink', 'Casket', and 'Sundari' were found to be tolerant to *Alternaria* and *Septoria.* From an evaluation of 347 hybrids, 100 open-pollinated seedlings, two hybrids and one open-pollinated seedlings have been selected and released. One mutant induced in 'Red Gold' with 3 Kr dose of gamma-rays was found to be promising for flower colour and floriferousness.

'Indira'. A hybrid between an open-pollinated seedling of 'Lord Doonex'(LD 114) and a hybrid seedling of 'Flirt' × 'Valentine'. Flowers double koreans, yellow at bud and buttercup yellow at picking measure 6 cm across. Released in 1980.

'Rakhee'. An open-pollinated seedling of cv 'Lord Doonex'. Plants bushy, compact with shining foliage. Flowers anemone, primrose-yellow with red stripes on ray florets, measure 6 cm across. Released in 1980.

'Red Gold'. Developed from a cross of 'Flirt' × 'Valentine'. Flowers grey-orange fading to golden yellow, double koreans and measure 6 cm across. Very floriferous. Released in 1980.

In farmers' fields 'Red Gold' and 'Indira' gave 163 and 88% higher income than a commercial variety 'Local Yellow'.

Gladiolus

Fourteen cultivars were found promising for cut-flower production, six were tolerant to *Fusarium* wilt, one small-flower variety, 'Mirage', from USA was superior in sprouting of corms, spike length, floret size and production of cormels. *Gladiolus callianthus* and 'Margaret Fulton', a cultivar, proved tolerant to *Fusarium* wilt. Six hybrids released in 1980 were evaluated from 1572 hybrids.

'Apsara'. A cross between 'Black Jack' × 'Friendship'. Spikes strong, 97 cm long; florets ruby red with barium-yellow flecks in throat, 18 per spike measuring 11 cm across. Released in 1980.

'Meera'. A cross between 'G.P.I.' × 'Friendship'. Spikes 90 cm long; florets snow white, 19 per spike, compact, measuring 12 cm across. Released in 1979.

'Nazrana'. A cross between 'Black Jack' × 'Friendship'. Spikes very strong, 104 cm long; florets cardinal red with barium-yellow flesh in throat, 18 per spike measuring 11.5 cm across. Released in 1979.

'Poonam'. A cross between 'Gelliber Herald' × 'R.N. 121'. Spikes 98 cm long; florets dresden yellow with mimosa yellow blotch, 17 per spike measuring 11 cm across. Released in 1979.

'Sapna'. A cross between 'Queen Woodpecker' × 'Friendship'. Spikes 83 cm long; florets barium-yellow with primrose yellow blotch and mandarin red tinge on margins, 17 per spike, compact, measuring 12 cm across. Released in 1979.

'Shobha'. A mutant of 'Wild Rose'. Spikes pleasing and 97 cm long; rachis 62 cm long; florets shell pink with empire yellow throat, 18 per spike, measuring 11.5 cm across. Released in 1980.

Bougainvillea

Six new cultivars of bougainvillea have been named and released. A colchicine-induced mutant with bright magenta bracts has been isolated from cv 'Zakariana'. A number of promising seedlings and bud sprouts with variegated leaves are under evaluation.

'Chitravati'. A hybrid of 'Lalbaugh' × 'Red Glory'. Plants drooping with large thorns; leaves light green, pubescent, medium elliptic to cordate ovate; bracts mandarin red, medium elliptic with acute tip, persistent. Released in 1979.

'Dr H.B. Singh'. A hybrid of 'Trinidad' × 'Formosa'. Leaves dark-green, glabrous, elliptic, with acute tip; bracts violet purple, medium to big, cordate. Released in 1977.

'Jawaharlal Nehru'. A spontaneous mutant of cv 'Lalbaugh'. Plants vigorous with compact growth habit; leaves variegated; moderately floriferous; bracts claret rose fading to orange red. Released in 1975.

'Purple Wonder'. A hybrid of 'Formosa' × 'Trinidad'. Plants erect with compact growth habit; leaves dark green pubescent, medium-size and elliptical; bracts violet purple, medium, ovate to elliptic and persistent. Released in 1979.

'Sholay'. A seedling selection of cv 'Red Glory'. Plants moderately vigorous; leaves dull-green, pubescent and of medium size; bracts delft rose, medium-size, hairy and elliptical, borne all along the branches. Released in 1977.

'Usha'. A seedling selection of cv 'Lady Hope'. Plants moderately vigorous, with erect habit; leaves dark-green, pubescent; flowering profuse, bracts magenta fading to mandarin red, hairy, borne all along the branches. Released in 1977.

Hibiscus

Rigorous screening of a large number of hybrid seedlings has resulted in selection and release of 25 cultivars which are floriferous and bear attractive flowers. Twelve important cultivars released between 1972 and 1979 are described.

'Aikta'. A cross between 'Debby Ann' × 'H.S. 203'. Moderately floriferous. Flowers single saucer-shaped, measuring 16–20 cm across, corolla red with deep red border. Released in 1976.

'Anuradha'. A hybrid of 'Debby Ann' × 'H.S. 48'. Very floriferous. Flowers single, slightly cup-shaped, measuring 14–16 cm across, corolla golden buff with reddish border. Released in 1978.

'Ashirwad'. A cross between 'H.S. 21' × 'Hombe Gowda'. Floriferous. Flowers single, measure 18–21 cm across, corolla orange, petals with slightly ruffled margin. Released in 1978.

'Bharat Sundari'. A selection from 'IIHR 1'. Floriferous. Flowers single, saucer-shaped, measure 17–19 cm across, corolla deep rose with light border.

Released in 1976.

'Chitralekha'. A hybrid of 'Debby Ann' × 'H.S. 203'. Flowers single, corolla China rose with frilled margin, white variegation in the centre of each petal. Released in 1976.

'Dilruba'. A hybrid of 'Debby Ann' × 'H.S. 203'. Very floriferous, flowers single saucer-shaped, measure 16–18 cm across, corolla dark golden buff with reddish brown margin. Released in 1976.

'Geetanjali'. A hybrid of 'Debby Ann' × 'Rachiah'. Very floriferous. Flowers single, measure 15–18 cm across, petals undulate incurved along the margin. Released in 1972.

'Ratna'. A hybrid of 'H.S. 127' × 'Ruffle'. Moderately floriferous. Flowers single, saucer-shaped, measure 14–15 cm across, petals slightly frilled, corolla yellow with almost white centre and orange red stripes. Released in 1979.

'Red Saturn'. A hybrid of 'H.S. 182' × 'Red Double'. Floriferous. Flowers double with ruffled petals, measure 10–12 cm across, corolla red without any conspicuous centre. Released in 1978.

'Phulkari'. A hybrid of 'H.S. 139' × 'H.S. 18'. Highly floriferous. Flower single, measure 17–19 cm across, corolla rose-coloured with prominent light purple rays and yellow border. Released in 1976.

'Smt. Indira Gandhi'. A hybrid of 'H.S. 182' × 'Ruffle'. Flowers single, saucer-shaped, measure 22–25 cm across, petals slightly recurved, corolla yellow with orange-red margin. Released in 1974.

'Tribal Queen'. A hybrid of 'IIHR 1' × 'H.S. 481'. Flowers single, saucer-shaped, measure 16–20 cm across, petals slightly recurved, corolla red with dark purple base. Released in 1972.

The other varieties released are 'Arunodaya' (Nasturtium orange), 'Basant' (sulphur yellow), 'Benazeer' (bright yellow), 'Jogan' (Azalea pink), 'Nartaki' (marigold orange), 'Nazneen' (tangerine orange), 'Neelofer' (magenta rose), 'Pakeezah' (carmine red), 'Priya' (rose Bengal), 'Queen of Hessaraghatta' (orange), 'Red Gold' (Dutch vermilion), 'Shanti' (primrose yellow), 'Smt Kamla Nehru' (rose Bengal).

Orchids

Special emphasis has been given to the work on orchids. The laboratory started in 1972 is now housed in a modern humidity-controlled orchidarium. Two promising new inter-specific hybrids have been evolved and are being multiplied.

'IIHR 164'. Vanda group (*V. rothschildiana* × *D. superbiens*). The hybrid is strap-leaved with flower spike 35-40 cm long bearing 9–15 red-purple flowers which stay for 60–75 days in perfect bloom.

'IIHR 38'. Dendrobium Group (*D. pompadour* × *D. superbiens*). The hybrid

is robust, floriferous with 8–15purple-violet flowers on 25–32 cm-long spike. The flowers last 2–3 months in full bloom.

China Aster

Evaluation of available germplasm led to selection of 25 pureline selections developed by single plant selection. Of these 'AST-1' and 'AST-2' were found to be very promising. Hybridization followed by repeated selections resulted in six promising purelines. In F_1 generation, heterotic effects were observed for earliness in flowering, stalk length, number of flowers per plant and size of flowers. 'AST-1' performed better than local varieties with regard to stalk length, colour, size, shape and number of flowers.

Other Crops

In rose 9 hybrids and 3 open-pollinated seedlings were found promising. One spontaneous mutant each isolated from 'Kronenbourg' and 'Arianna' are under evaluation. A free-flowering mutant with regular bicoloured flowers possessing white and red stripes was isolated in petunia after treating the seeds of variety, 'Resist Red' with gamma-rays at 10 Kr.

Fifteen promising croton hybrids were named and released.

AGRO-TECHNIQUES

Rose

A new thornless rose rootstock has been identified which facilitates easy budding. This rootstock is suitable for closer planting system. In a rootstock trial maximum bud-take was observed when *Rosa multiflora* was used as a rootstock. It was found that 'Happiness' budded on this rootstock produced significantly more number of export-quality flowers than when it was budded on *R. indica.*

GA spray at 10–100 ppm increased flower yield in 'Queen Elizabeth'. On its own roots 'Queen Elizabeth' appeared promising for garden display.

Chrysanthemum

Suckers exposed to 16 hr continuous light daily for $2\frac{1}{2}$ months produced plants with longer and stiffer stalks, with larger and thick-petal flowers as compared to plants raised under natural light (13–14 light hr).

Cycocel (50 ppm) and 8-hydroxyquinoline citrate (200 ppm) were found to be the best chemicals for prolonging the vase-life of chrysanthemum cut-flowers.

Tuberose

In a varietal trial with four cultivars, 'Single' produced highest number of spikes. In an agronomical trial on 'Double' bulk size of 2–2.5 cm, planting depth

of 5 cm and spacing of 20 cm gave good growth, flowering and bulb production.

In a nutritional trial on 'Single' a dose of 20 g of N and 40 g P_2O_5 per m^2 was found to be optimum. Potash was not found to be effective on growth and flowering. The corm weight increased significantly with the application of 30 g of P_2O_5.

Planting during April-May appeard to be optimum for 'Single'. However, pre-planting treatment of tuberose 'Single' bulb with GA_3 significantly increased the rachis length.

Carnation

Carnation could be sown between June and January with varying degrees of success. However, sowings between October and December resulted in good plant growth and in high yield of good-quality flowers. Also, a spacing of 40 cm × 40 cm was optimum for higher yield and good-quality flowers.

Carnation should be punched between 80 and 90 days after sowing for better plant growth, flower yield and good-quality flowers. Disbudding of axillary flower buds should be done within 7 days of the appearance of axillary buds for better quality flowers.

Nitrogen was more important for growth and flowering compared to P_2O_5 or K_2O.

NAA at 500 ppm promoted branching and ethrel at 500 and 1000 ppm was effective in reducing the plant height.

Jasmine

In *Jasminum sambac*, 'Gundumalli' pruned in the third week of November gave maximum flower yield. Pruning to 28 and 24 branches was better. Pruning at 70 cm shoot length was best to get maximum flower yield.

Chemical defoliation with Boll's eye at 3000 ppm proved best for getting maximum flower yield and good flower quality along with 80-85% defoliation.

A plant density of 17,777/ha gave significantly higher flower yield (4,547 kg) followed by plant density of 10,000/ha (2977.17 kg).

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Floriculture Research at the IARI

N.K. Dadlani, R.S. Malik and **B. Choudhury**
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New Delhi

RESEARCH on floriculture started at the Indian Agricultural Research Institute, New Delhi (IARI), in the late fifties. This work was initiated in the Division of Botany under an ICAR scheme entitled 'Scheme on Cytological and Physiological Studies in Relation to Floriculture'. However, the Division of Horticulture was established in March 1956 to work on the improvement of fruits and vegetables including post-harvest technology. Due to the keen interest and efforts of Dr B.P. Pal, the then Director of the Institute, scientific research in floriculture was initiated in the Division of Horticulture in 1958–59. A small unit took up the work on ornamental gardening, with special attention on roses. Research on floriculture was simultaneously started at the Regional Station of the Institute at Katrain (Kulu Valley) and at Simla, primarily to undertake assessment and improvement work under temperate climatic conditions. In 1959–60, a co-ordinated scheme on floriculture of the ICAR came in operation at various centres including IARI, mainly for work on roses. A comprehensive collection of rose varieties, called the National Rose Collection, was built up. Dr Pal very generously gifted a large number of rose varieties from his personal collection maintained in the garden attached to his official residence. The National collection has by far remained the largest and the best in the country with over two thousand rose varieties and *Rosa* species introduced from sources within and outside the country. At about the same time, through the courtesy of Dr M.S. Randhawa, the Vice-President of ICAR, a large number of ornamental flowering trees and shrubs, were introduced.

The research work on floriculture in the Division of Horticulture was further extended with bifurcation of the Division into the Division of Vegetable Crops of Floriculture and the Division of Horticulture and Fruit Technology during 1971. However, in 1983 the Division of Floriculture and Landscaping separated from the Division of Vegetable Crops and Floriculture which gave an additional boost to independent research on Horticulture.

For more than a quarter of a century, the work in ornamental horticulture at the IARI, has proved to be the guiding force for floriculture research in the country. Whereas initially, the work was taken up on a large number of ornamental plants, the research efforts in the recent years have been concentrated on the improvement of rose, gladiolus, bougainvilleas and a few annuals to avoid duplication of research efforts at various agricultural universities and the IIHR, Bangalore.

The co-ordinated scheme on floriculture initiated in 1960 on roses formed the basis for strengthening of floriculture work under the Third Five-Year Plan. During the latter part of the Fourth Plan, an All-India Co-ordinated Floriculture Improvement Project was started by ICAR with IARI as the headquarters of the Project Co-ordinator and also as one of the main centres of research on floriculture.

In recognition of the meritorious work done by the Division it was designated as the International Registration Authority for Bougainvillea and the National Registration Centre for Roses by the International Society of Horticultural Science. Therefore, the first check-list describing more than 300 cultivars of bougainvilleas was published (Choudhury and Singh 1981).

CROP IMPROVEMENT

Rose

Rose, the world's favourite flower, is the most researched upon ornamental flower at this Institute. The main thrust in the improvement has been on breeding new varieties of roses, suited to the tropical Indian conditions for garden display, as well as for cut flowers.

A comprehensive germplasm collection of over two thousand rose varieties and species during the twenty five years, called the National Rose Collection, provided the best material for rose breeding. This includes hybrid tea, floribunda, polyanthas, miniature, climbing roses and several *Rosa* species introduced from abroad through National Bureau of Plant Genetic Resources (formerly Division of Plant Introduction at the IARI), and other sources within the country. The experience gained with the assessment of the germplasm indicated that while some of the famous roses, namely 'Super Star', 'Queen Elizabeth' and 'First Prize' introduced from abroad, performed well under our conditions, there were also instances of highly acclaimed exotic varieties like 'Peace' and 'Uncle Walter' proving a failure here.

The breeding of roses at the IARI started in the early sixties. Dr Pal developed some hybrid seedlings and released his first rose vareity 'Rose Sherbet' in 1962. It was highly fragrant, with 0.033% oil content.

The main objectives of rose breeding are to evolve varieties with attractive

flower colour and form, fragrance, floriferousness, disease and insect-pest resistance and their suitability for growing under sub-tropical conditions. Experience gained through numerous basic studies conducted at IARI, suggested the possibility of directed breeding for desired objectives. With the approaches of genic manipulation, chromosome engineering using aneuploidy and induced mutations, much success has been achieved in the improvement of roses (Malik and Dadlani, 1980).

Shahare and Shastry (1963) studied the meiosis of 96 varieties of garden roses. They observed that while euploid numbers are most frequent, in exceptional cases, aneuploid numbers were also recorded. Inter-varietal variation in chromosome pairing was reflected in varying degrees of expression of univalents, heteromorphic bivalents, bivalents with double secondary constrictions and multivalents. They also recorded supernumerary fragments in addition to the euploid chromosome complement in three varieties and also reported chromosomal numercial mosaics in three floribunda and one hybrid polyantha varieties. Meenakshi (1977) developed a quick and less cumbersome method for obtaining mitotic chromosomes from leaf tips. This was found extremely useful, as the mitotic chromosomes could then be studied the year round. Swarup *et al.* (1973) and Meenakshi (1977), observed most of the garden rose varieties to be tetraploid (4x=28) while some were triploid (3x=21). Swarup *et al.* (1973) found one of the varieties 'Mohini' to be an aneuploid with 22 (21+ 1) chromosomes.

Mathew (1985) studied a few basic aspects like stigma receptivity, pollen viability, method, time and season of pollination to exploit the limited favourable period for better seed set and seed germination in rose. She observed that maximum stigma receptivity was one to two days after anthesis.While the period of receptivity was longer in winter than spring, the percentage of hips set during winter was lower compared to spring. This was attributable to low mean temperature during this period. Pollination done at 12 o'clock in the day gave the highest hips set. Self-pollination gave higher percentage of hips set than those observed in cross pollination. The best set was, however, found in open-pollination. The hip formation was faster and better in spring than in winter. With regard to germination of seed, the normally practised method of stratification for three months did not prove effective and the best results were obtained when seeds from green hips of 'Delhi Princess' stratified for one month, and in 'Esperanza' from settled seeds (unstratified) and washed seeds (stratified).

It was established that parents for hybridization, should be chosen from varieties known to possess high female and high male fertility, such as 'Pink Parfait', 'Swati', 'Sweet Afton', 'Charles Mallerin', 'Crimson Glory', 'Golden Splendor', 'Buccaneer' (Swarup *at el.*, 1973). Parents having two or more colour combinations in their flowers, when crossed with parents having self-coloured

flowers showed that the segregation of flower colour was more variable than when both parents are self-coloured. Crosses among whites or yellows thus produced hybrids having flowers like those of parents only. A greenish-white flower variety crossed with a pure white one showed greenish-white to be dominant. Deep yellow was found to be recessive to the light yellow and dark red to shades of pink (Swarup *et al.*, 1973). Segregation for flower fragrance in hybrids was higher (75%) where both parents, 'Sweet Afton' and 'Avon', were fragrant as compared to crosses in which only one parent, 'Sweet Afton', 'Avon', 'Charles Mallerin', 'Oklahoma' or 'Prelude' was fragrant. However, they also observed some hybrid seedlings with fragrant flowers even in crosses when none of the parents were fragrant, 'Message' × 'Virgo', 'Western Sun' × 'Golden Splendor' and 'Buccaneer' × 'Golden Splendor'. A good rose flower must have sufficient number of petals, the optimum number being 30–50 petals. On crossing two double-flowered cultivars, there is a wide segregation of the number of petals in the hybrid progenies. In almost all the crosses, the percentage of single and semi-doubled flower seedlings was higher than the fully doubled ones (Swarup *et al.*, 1973).

From several thousand crosses made each year and the critical evaluation of the hybrids from at least three years, nearly 150 rose varieties have been developed at this Institute since 1960, including those developed by Dr Pal. The varieties developed in different classes of roses are:

Hybrid Tea. 'Abhisarika' (1975), 'Akash Sundari' (1982), 'Anurag' (1980), 'Apsara' (1982), 'Arjun' (1980), 'Aruna' (1968), 'Ashirwad', 'Belle of Punjab' (1965), 'Bhim' (1970), 'Chambe Di Kali' (1983), 'Charugandha' (1972), 'Chitralekha' (1972), 'Chitwan' (1971), 'Dark Boy' (1965), 'Delhi Apricot' (1964), 'Delhi Debutante' (1964), 'Delhi Pastel' (1964), 'Delhi Sunshine' (1963), 'Dil-ki-Rani' (1985), 'Dilruba' (1984), 'Diva Swapna' (1981), 'Dr B.P. Pal' (1980), 'Dr Homi Bhabha' (1968), 'Dr R.R. Pal' (1983), 'Dulhan' (1983), 'Eastern Princess' (1984), 'Ganga' (1970), 'Golconda' (1968), 'Golden Afternoon' (1984), 'Gulbadan' (1976), 'Gulzar' (1971), 'Hans' (1970), 'Haseena' (1979), 'Indian Princess' (1980), 'Jawani' (1985), 'Kanakangi' (1968), 'Kulu Belle' (1972), 'Lal Makhmal' (1983), 'Lalima' (1978), 'Madhosh' (1975), 'Madhumati' (1973), 'Madhushala' (1973), 'Mehak' (1977), 'Meghdoot' (1972), 'Mridula' (1975), 'Mrinalini' (1972), 'Nandini' (1983), 'Nayika' (1975), 'Nazneen' (1969), 'Nishada' (1983), 'Nurjehan' (1980), 'Pahadi Dhun' (1981), 'Patrani' (1981), 'Pale Hands' (1965), 'Pink Montezuma' (1980), 'Poornima' (1971), 'Priyadarshini' (1986), 'Pusa Christina' (1975), 'Pusa Sonia' (1986), 'Raat-ki-Rani' (1975), 'Raja Surendra Singh of Nalagarh' (1975), 'Raj Hans' (1983), 'Raj Kumari' (1973), 'Raktagandha' (1975), 'Rampa Pal' (1975), 'Rangshala' (1969), 'Ranjana' (1975), 'Ratnaar' (1985), 'Rosy Evening' (1985), 'Sandeepini' (1983), 'Scented Bow' (1965), 'Soma' (1980), 'Sugandhini' (1969), 'Surkhab' (1976), 'Sweet Innocence' (1980), 'Sujata' (1971),

'Surabhi' (1975), 'Surekha' (1969), 'Uttam' (1969), 'Vasant' (1980), and 'White Nun' (1968).

Floribunda. 'Akash Nartaki' (1983), 'Arunima' (1976), 'Azeez' (1965), 'Banjaran' (1969), 'Celestial Star' (1965), 'Chamba Princess' (1967), 'Chandrama' (1980), 'Chingari' (1976), 'Chitchor' (1972), 'Deepak' (1977), 'Deepika' (1975), 'Deepshikha' (1975), 'Delhi Brightness' (1963), 'Delhi Daintiness' (1963), 'Delhi Maid' (1963), 'Delhi Pink Powderpuff' (1965), 'Delhi Prince' (1963), 'Delhi Princess' (1963), 'Fugitive' (1965), 'Himangiri' (1968), 'Jantar Mantar' (1982),

Fig. 1. Rose 'Arunima' (Fl.)

Fig. 2. Rose 'Chandrama' (Fl.)

'Kavita' (1972), 'Kumkum' (1971), 'Loree' (1969), 'Madhura' (1979), 'Mohini' (1970), 'Nav Sadabahar' (1980), 'Navneet' (1971), 'Neelambari' (1975), 'Nutkhut' (1969), 'Orange Cup' (1974), 'Paharan' (1971), 'Panchu' (1966), 'Parwana' (1974), 'Prema' (1970), 'Ragini' (1972), 'Rajbala' (1975), 'Rose Sherbet' (1962), 'Rupali' (1971), 'Sadabahar' (1969), 'Sailoz Mookherjee' (1974), 'Sandhya Bela' (1971), 'Saroja' (1984), 'Shabnam' (1975), 'Shola' (1969), 'Shringar' (1972), 'Sindoor' (1980), 'Stanza' (1967), 'Suchitra' (1972), 'Suhashini' (1972), 'Surya Kiran' (1979), 'Suryodaya' (1968), 'Temple Flame' (1965), 'Usha' (1975).

Miniature. 'Delhi Starlet' (1963)

Polyantha. 'Swati' (1979).

Climbers. 'Clg. Dr Homi Bhabha' (1975), 'Delhi Pink Pearl' (1962), 'Delhi White Pearl' (1963).

A large number of these varieties have become very popular with the rose

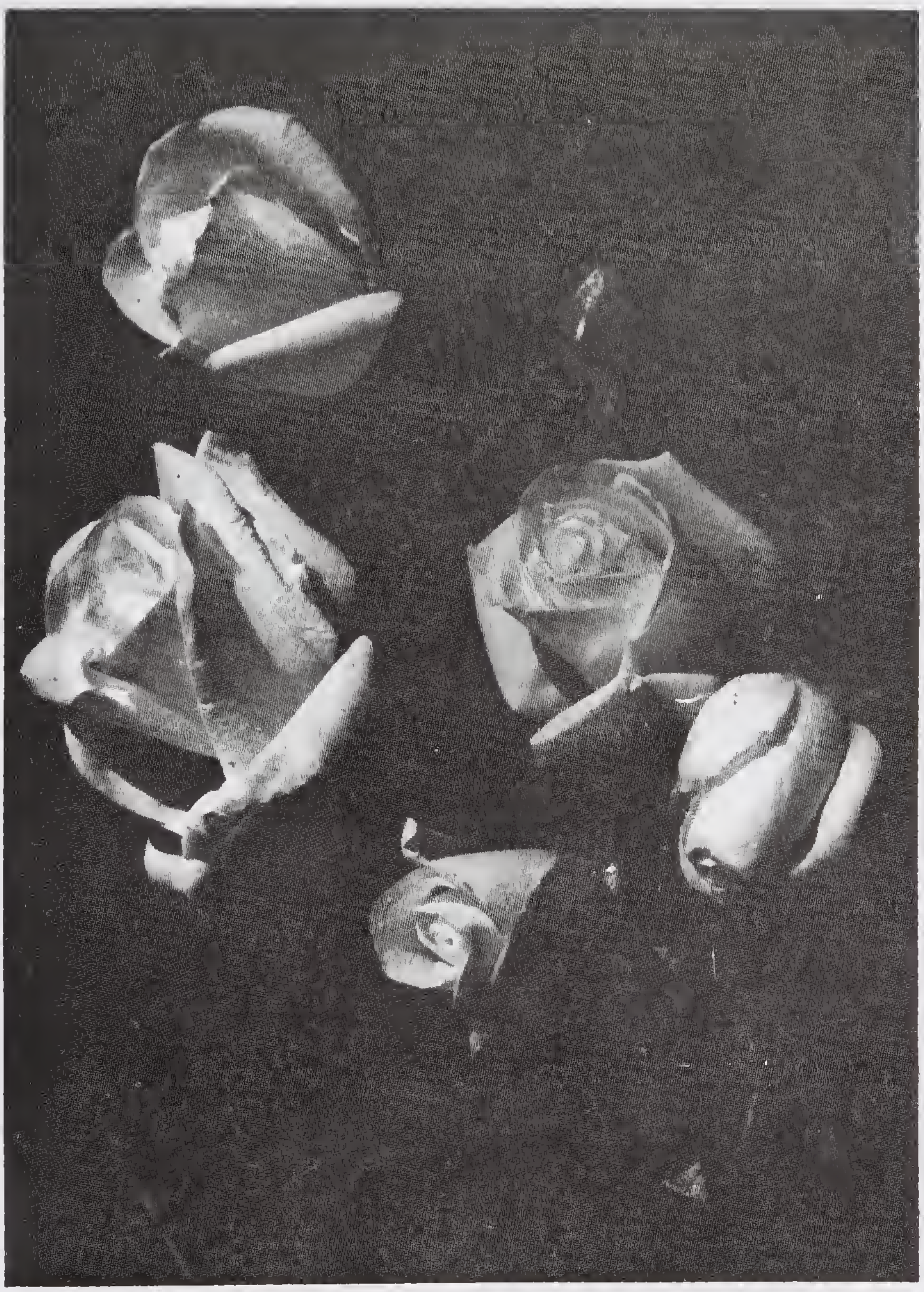

Fig. 3. Rose 'Prema' (Fl.)

growers in the country. Some of them have competed well with the exotic varieties and many a times won prizes at various Rose/Flower Shows held in our country. 'Banjaran' has won several prizes in the USA also. 'Mohini' with its unusual chocolate colour, was considered for patenting by a reputed American Rose Nursery (M/s Jackson & Perkins, California). Three of the varieties were developed through the use of induced mutation. Induced mutants, 'Abhisarika' from 'Kiss of Fire', 'Pusa Christina' from 'Christian Dior' and 'Madhosh' from

'Gulzar' were developed from treatments, 5–10 Kr gamma-rays among the physical mutagenic treatments and 0.2% NMU among chemical mutagens.

Samples of flowers from different varieties in collection, were analysed in as early as 1962 and out of the varieties tested, 'Rose Sherbat' developed by Dr Pal yielded the highest oil content (0.033%). Different clones of *Rosa damascena*, the Damask Rose, were also collected from sources within the country and abroad. Crosses were attempted to combine the free-flowering nature of the scented damasks and winter flowering of various rose varieties. An assessment of various *damascena* clones showed that while the Bulgarian material produced more flowers, collections of Hasayan region (Aligarh, Uttar Pradesh) bear more petals per flower. The attempts at combining the suitable characters of damasks and modern roses, were mainly carried out at Shimla where *R. damascena* set fruits freely. On the contrary no fruiting was observed at Delhi.

Attempts were also made to breed rose ramblers suitable for growing in plains, since ramblers flower late in spring in the plains and fade quickly. The crosses were made at Shimla and F_1 seedlings assessed in plains.

Gladiolus

Gladiolus breeding at the IARI started in the nineteen seventies and the Institute released in 1980 three improved varieties, 'Agnirekha' (fire-red florets, with scarlet stripes and saffron yellow eye), 'Mayur' (lilac-purple with dark-purple throat) and 'Suchitra' (camellia-rose florets with vermilion blotch and dianthus-purple eye) (Singh and Dohare, 1980).

In *Gladiolus*, it was previously believed that the dormant corms have to be obtained from the hills for growing a successful crop in the plains of India. This was due to the fact that the corms get spoiled during their resting period in the heat of northern plains. Cold storage of corms and their treatment with fungicide, both before storage and before planting, was standardized which made it possible to grow a commercial crop of gladiolus.

'Apple Blossom', 'Bis Bis', 'George Mazure', 'Melody', 'Oscar', 'Ratna's Butterfly', 'Snow Princess', 'Sylvia' and 'Vink's Glory' are recommended for growing in the plains.

Misra and Choudhury (1976) evaluated more than 100 commercial gladiolus cultivars and recommended 37 cultivars to be suitable for growing in the hills of Himachal Pradesh. Misra (1983) and Misra and Choudhury (1977) reported a few promising hybrids from the hybridization work attempted in gladiolus.

Bougainvillea

In *Bougainvillea*, five highly floriferous cultivars namely 'Dr R.R. Pal', 'Sonnet', 'Spring Festival', 'Summer Time' and 'Stanza' were evolved by Dr Pal. Among these, 'Dr R.R. Pal' is very vigorous and also makes a good rootstock for

the budding of bougainvillea varieties difficult to propagate otherwise. 'Vishakha' was also developed at this Institute. Swarup and Singh (1964) recommended a key for classification of *Bougainvillea* cultivars using pollen morphology and leaf hairs.

Zinnia

Zinnia is a very popular annual flower during summer and monsoon. Unfortunately, leaf-curl viral disease seriously hampers its cultivation in the northern plains. By recurrent selection from the irradiated seeds of *Zinnia elegans*, a mixed-coloured variety, a resistant variety, has been evolved (Swarup and Raghava, 1974).

Marigold

Singh and Swarup (1971, 1973 a, b) studied in detail the inheritance of various characters in African marigold. They observed appreciable heterosis for the 8 characters studied. They reported that while dominance and epistasis played a major role in the inheritance of days to first-flowering and flower weight; additive gene effects and epistasis, were found to be predominant in number of flowers. The dubleness of flowers was a monogenically dominant character. However, the type of flowers and their colour was each governed by two genes. Also there is a transgressive segregation for various characters in the F_2 generation, which indicates the importance of such a segregation in the improvement of various characters.

Antirrhinum

Malik (1979), in genetical studies with the diploid and tetraploid progenies of snapdragon, *Antirrhinum majus*, observed appreciable heterosis in the F_1 hybrids for all the characters studied, with the heterosis being more pronounced in diploids than in tetraploids. Over-dominance was noticed in the inheritance of all the characters; but, selection may be effective in improving a few characters where complementary epistasis was observed. Dominance component of variance was higher than the additive component of variance.

Balsam

Swarup *et al.* (1975) observed heterosis for all the characters studied in diallel crosses made in balsam (*Impatiens balsamina*) and reported better performance of F_1 hybrids than the top parent. Gene action was additive in nature without any epistasis, for all the characters except, for flowers per plant, where complementary epistasis was observed. However, in the absence of a convenient and economical method of F_1 seed production, even though appreciable heterosis was observed for all characters, it was better to fix the economic factors by

selection in F_2 and further generations, and the pure-lines isolated with superior economic characters may be further crossed to exploit the heterosis.

Other Crops

Induced mutation was studied in several annuals including annual chrysanthemum, cosmos, pansy, cynoglossum, Bells of Ireland (*Molucella laevis*), *Tithonia rotundifolia* and sweet pea (*Lathyrus odoratus*) and interesting results were obtained in some cases. In annual chrysanthemum, Jain and Mazumdar (1957) and Jain *et al.* (1961) observed changes in flowers from single to double of various types and from non-tubular to tubular corolla. In Bells of Ireland, mutants for dwarf plant height and reduced branching were obtained with 15 Kr gamma-rays treatment. In *Tithonia* 20 Kr gamma-rays induced mutations for leaf chlorophyll, flower form and colour, consequently, mutants with yellow flowers, striped ray petals and tubular petals were also obtained. In sweet pea, 0.25 and 0.5% BMS-treatment induced changes in flower form by producing flower with 1–2 additional 'standard' on an additional 'keel', giving the appearance of a large double flower (Kaicker *et al.*, 1972).

So far, enough attention has not been paid to flowering trees and shrubs. Swarup and Singh (1965), while studying the morphological plant characteristics of different ornamental flowering *Cassia* species, observed three unusual trees which differed from the known *Cassia* species in several characters. On a detailed study, these trees were found to be natural inter-specific hybrids between the yellow-flower *Cassia fistula* and the pink-flower *C. nodosa*. One of these hybrids, was outstanding in beauty and flowering as a new ornamental flowering cassia. In fact Dr Pal had first noticed one of these hybrids and drew the attention of the initiation of these studies.

Swarup *et al.* (1973) observed in hollyhock (*Althea rosaea*) that there is high heterosis in the inter-varietal crosses for most of the characters studied (Swarup *et al.*, 1973). The estimates of heritability in broad sense were also high and genetic advance was high for characters—flowers on side branches, flower weight and flowers on main stem. Days-to-flowering had significant positive correlation with flower size and flower weight.

Sharma and Swarup (1962) studied the chromosome numbers and the meiosis in some wild ornamental shrubs found in the Kulu Valley. Swarup *et al.* (1963) observed a few plants of *Tulipa stellata* having complete tetramerous flowers and some intermediate types between trimerous and tetramerous conditions, where otherwise trimerous character was the regular character.

At the IARI Regional Station, Katrain, assessment of a large collection of various ornamental crops, yielded two new types of *Coreopsis tinctoria*, one with tubular or fluted ray florets and another with star-shaped florets. A natural mutant of calendula with ray florets of cactus type was also seen.

AGRO-TECHNIQUES

As mentioned earlier, major programmes of work on ornamental crops at the IARI were related to crop improvement. Research efforts on agro-techniques have been limited.

Rose

The product on technology for roses for cut-flower was studied in depth and standardized. With regard to planting distance, it was observed that while the commonly used spacing of 60 cm × 60 cm produced the highest number of flowers per bush, maximum production from a unit area was recorded with the closer spacing of 60 cm × 30 cm. Experiments to study the effect of time and severity of pruning on flower production revealed that low pruning (10 cm) done on 8 October produced the highest number of first-grade flowers in 'Queen Elizabeth', 'Super Star' and 'Happiness'. With regard to nutrition requirements, it was concluded that higher dose of nitrogen application at 20 q/ha increased production of cut-flowers significantly (Malik, 1980).

Blooms kept at 4.5–10°C for 6–8 hours had the best keeping and transport qualities which helps in the export of the cut-flowers. Four-trial consignments of cut blooms sent to Europe (Paris, Frankfurt and Rotterdam), through State Trading Corporation of India, were very well received and appreciated by the importing florists (Swarup *et al.*, 1972).

The choice of rootstock in judging the potential of the genotype of the seedling of a variety is an important consideration. The Institute, identified a new rose rootstock *R. indica* var. *odorata*, which was superior to the commonly used rootstock of the region, i.e. 'Edouard Rose' (*R. bourboniana*). This new rootstock had better bud-take (80–100%) as well as high multiplication ability through cuttings (89.78% success) than the other rootstocks tested (Swarup and Malik, 1974).

Gladiolus

Certain growth regulators and chemicals can be used to enhance corm and cormel production in gladiolus (Sehgal, 1984). Benzyl adenine, Etherel and Thiourea are generally suitable for normal crops raised from corms, while isopropyl myristate and ascorbic acid are more effective when the crop is grown from cormels or corm sections. Tissue-culture studies demonstrated that gladiolus multiplication can be considerably speeded up by *in vitro* propagation, starting with spike segments or cormel buds. Dormant cormels can be harvested from culture-vessels, or after transplanting the cultured plantlets in pots. The optimum treatments for desirable effects under field conditions as well as in aseptic manipulation vary with the cultivar.

Bougainvillea

In the standardization of propagation technique for some ornamental crops, Singh *et al.* (1976) found better rooting of bougainvillea cuttings under bottom heat.

Hibiscus

Singh (1979) observed patch budding and veneer grafting to be successful methods for propagation of the otherwise difficult-to-propagate Hawaiian hibiscus varieties under Delhi conditions.

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3

Floriculture Research at the NBRI

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FLORICULTURE has become a lucrative industry in many countries as a result of science-based techniques and steady supply of improved plant material. There is considerable trade of flowers in our country, spread over 10 states covering more than 20,000 ha. The application of innovative technologies can give impetus to its improvement. It is in this background that multi-disciplinary research was carried out at the National Botanical Research Institute (NBRI), Lucknow, involving germplasm collection, assessment, propagation, improvement, standardization of agro-techniques and protection to serve the industry by finding solutions of the major problems of growers, nurserymen and florists (Kher and Bhutani, 1979).

INTRODUCTION AND CONSERVATION

Introduction, collection, and long-term preservation of germplasm of plant materials through conventional methods and long-term culture of proliferating shoots or plantlets *in vitro* have made the institute a National Repository of living collection of important ornamentals, viz., *Amaranthus* (300 accessions), *Amaryllis* (6 spp. and 56 cvs), *Bougainvillea* (160 spp./cvs), *Canna* (80 cvs), *Chrysanthemum morifolium* (400 cvs),*Gladiolus* (55 cvs) and *Rosa* (700 cvs). This formed a broad genetic base for further improvement and research.

Using tissue-culture techniques, preservation of ornamentals as ‘Tissue Banks’ has been attempted. The protocorms and very young plantlets of *Vanda* hybrid, *Rhynchostylis retusa* and *Dendrobium· chrysotoxum* have proliferated *in vitro* for more than seven years. Millions of plantlets with developed shoot and root systems could be produced for propagation from such ‘Tissue Banks’. Growth requirements for different stages of plantlet formation i.e., proliferating plantlets, individual growth of plantlets with

promotion of shoot, promotion of rooting and transplantation of the *in vitro*-raised plants to pots had been worked out. Similarly, Tissue Banks of different cultivars of *C. morifolium* have been maintained in long-term culture for more than eight years by periodic subculture of their shoot apices, which could be proliferated to obtain the requisite number of cloned plants of particular cultivars at any time of the year (Prasad *et al.*, 1983). In both the cases, true-to-type plants were produced since the regeneration was different from the explant without intervening-callus formation.

IMPROVEMENT

Creation of new cultivars of ornamentals, especially of indigenous origin suited for cultivation in the Indo-Gangetic Plains, was achieved by employing selection, hybridization, polyploidy and mutation breeding. This should provide a sound scientific base to the floriculture trade in India which has so far mainly depended on import of quality seed material from abroad. The imported material is mostly unsuitable for local conditions. If F_1 hybrids are imported, they degenerate in subsequent generations, resulting in an unending cycle of imports. For a sound scientific approach, it is essential that basic genetic information is obtained through the study of breeding systems, experimental hybridization and synthesis of autoploids and amphiploids involving both the cultivated and the putative wild species.

Such studies have permitted us to chart out genetic-evolutionary race histories for *Antirrhinum, Amaranthus, Bougainvillea, Canna, Chrysanthemum, Gladiolus, Amaryllis, Hibiscus, Lantana* and *Verbena* (Khoshoo, 1979). The information generated by these studies have helped in the circumscription of 'gene pools' and their utilization in the creation of new and novel cultivars of commercial importance suitable to Indian agro-climatic conditions. Utilising the above approaches some of the significant results achieved are as follows.

Selection

Chrysanthemum. Selection from seedlings raised from pollinated seeds resulted in evolution and release of several outstanding cultivars which have since been very well received by the industry, e.g., in chrysanthemum 'Apsara', 'Birbal Sahni', 'Jayanthi' and 'Kundan', have been recognized as much superior to existing ones for cut flower owing to their attractive blooms borne on erect stems and long-lasting quality. Similarly, in the evolution at NBRI of the dwarf 'no pinch no stake' type cultivars, namely 'Sharad Singar', 'Hemant Singar', 'Suhag Singar' and 'Guldasta' (Fig. 1), the growers of potted chrysanthemums have found an answer to their

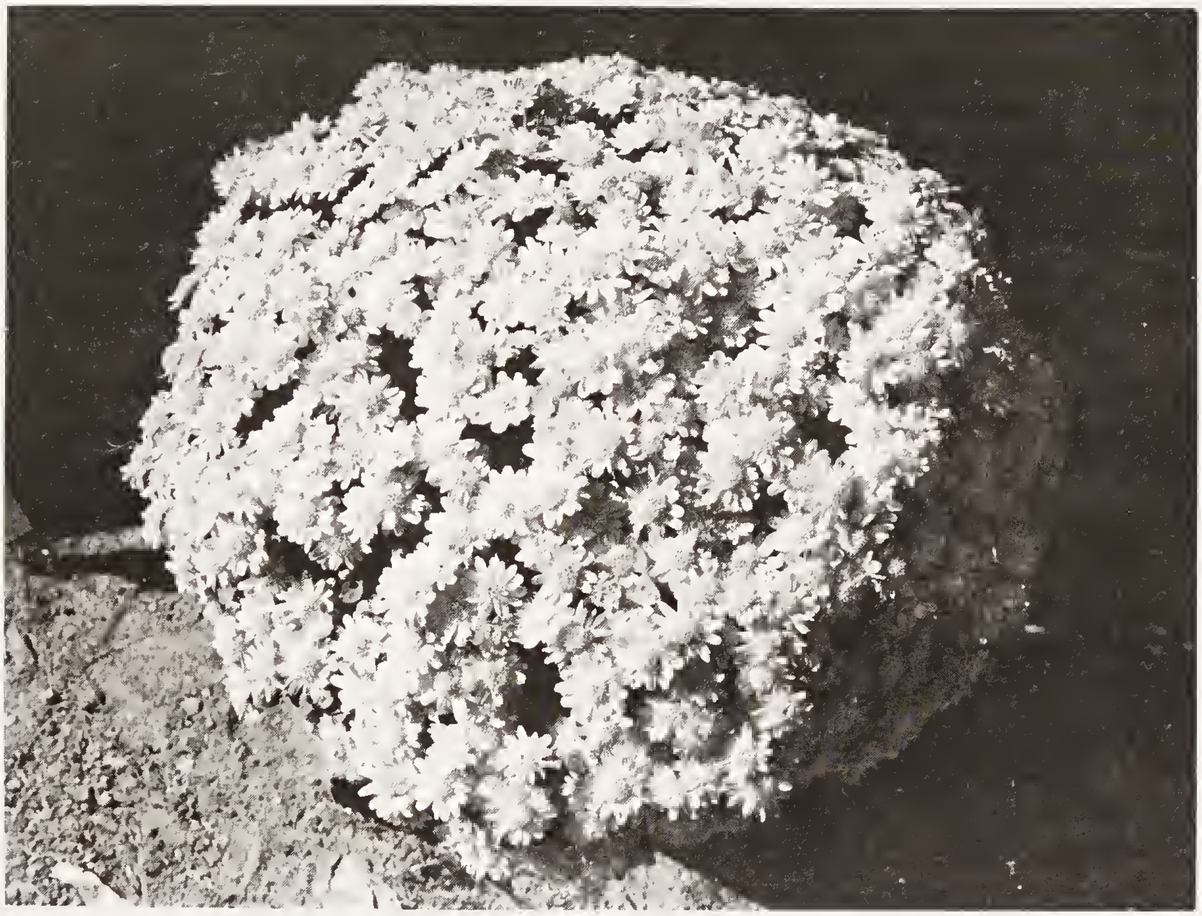

Fig. 1. *Chrysanthemum* cv. 'Guldasta'– a 'no pinch no stake' variety.

age-old problem of training the plant which called for a lot of skill, time and labour. The evolution of summer, the rainy season and spring blooming varieties on the other hand have solved the proverbial problems of short blooming period in chrysanthemum specially in North India.

Gladiolus. A decade ago it was believed that *Gladiolus* could only be grown commercially in hills. The success of *G. psittacinus* hybrid at the NBRI inspired research on evolving different-coloured varieties suitable for growing in the plains. Notable among these are 'Jwala', 'Priyadarshini' and 'Gazal' all of which are open-pollinated seedling-selections whereas 'Kohra' is a cross between (*G. psittacinus* hybrid × 'King Leaf'). Corms of these four varieties can be stored in ordinary room conditions in contrast to the exotic hybrids which require cold storage during hot months.

Bougainvillea. The evolution of *Bougainvillea* 'Shubhra' has fulfilled the long-felt desire of having white-bractate, free and perpetual blooming, hardy and easy-to-multiply *Bougainvillea* cultivar (Sharma, 1969).

The following outstanding cultivars (Bud sports) of *Bougainvillea* have been evolved:

'Shubhra'. Bud sport of 'Mary Palmer'; bracts parchment white, profuse bloomer.

'Dr B. P. Pal'. Tetraploid of 'Shubhra'; bracts parchment white, seed bearing due to induced fertility.

'Tetra Mrs McClean'. Tetraploid of 'Mrs. McClean'; Bracts brunt orange, seed bearing due to induced fertility.

'Begum Sikander'. Hybrid seedling of 'Dr B.P. Pal' × 'Dr B.P. Pal' × 'Jennifer Fernie', aneuploid (2n=3x–2=49); bracts bicoloured with magenta margin and parchment white centre/restricted growth.

'Mary Palmer Special'. Hybrid seedling of 'Dr B.P. Pal' × 'Princess Margaret Rose', Triploid (2n= 3x=51); Bracts bicoloured magenta and white.

'Chitra'. Hybrid seedling 'Tetra Mrs McClean' × Dr B.P. Pal'; bract multicoloured magenta, parchment white and orange.

'Archana'. Bud sport of 'Roseville's Delight'; Leaves variegated.

'Wajid Ali Shah'. Hybrid of 'Dr B.P. Pal' × 'Mrs. Chico' and is a triploid (2n = 3x = 51), with irregular blotches of rose in purple and parchment white.

'Shweta'. Bud sport of 'Trinidad'; bracts reflexed, greenish white.

'Parthasarthy'. Bud sport of 'Partha'; Foliage variegated, variegation irregular.

'Surekha'. Bud sport of 'Scarlet queen'; Leaves variegated with cream yellow patches.

'Nirmal'. Bud sport of 'Mrs. McClean'; leaves variegated green with yellow patches.

Hybridization

Bougainvillea. Progress in bougainvillea breeding has been hampered all over the world largely because of the extensive pollen and/or seed sterility. The choice of female and male parents is limited only to the few relatively fertile types which, more often are not good cultivars. After detailed studies of the reasons for sterility, fertility was restored by colchiploidy. This enabled immediate broad-basing of germplasms by inclusion of such cultivars in breeding programme that were otherwise very useful but so far out of reach of bougainvillea breeders all over the world. Following the method outlined here, there are now available seeded counterparts of several sterile but very popular varieties like 'B.P. Pal' from 'Shubhra' and 'Tetra Mrs McClean' from 'Mrs McClean'. These have been used to raise a number of very promising, colourful, and floriferous often bicoloured hybrid varieties at triploid, tetraploid and aneuploid levels. Some of these are ideal for pot culture. Special mention may be made of 'Begum Sikander', 'Wajid

Ali Shah', and 'Mary Palmer Special'. This work has also led to the development of varieties with blotched bracts as in 'Chitra' resulting from 4x 'Mrs Cleans' (2n=68) × 'Dr B.P. Pal' (2n=68) (Zadoo, 1974; Zadoo *et al.*, 1975; Sharma and Ohri, 1982).

Snapdragons. F dwarf hybrid snapdragons were evolved using inbred lines of the conventional snapdragons selected on the basis of their height, compactness of inflorescence, number of flowering stems per plant, blooming period, number of flowers opening at a time, number of flowers per inflorescence, size, colour and duration of flowers and fertility. These lines were pollinated with a dwarf species, *Antirrhinum glutinosum.* The resultant F_1 hybrids are uniform with semi-dwarf habit and large number of tillers with prominently held inflorescence bearing closely set reasonably large flowers. A desirable attribute is their perfectly synchronous intershoot, intertiller and interplant flowering (Mahal, 1972; Khoshoo, 1979).

Tetra-giant snapdragons. These were raised from some F_1 hybrids giving good performance under Indian conditions. The resultant tetraploids are hardier, sturdier, stockier and shorter than the corresponding diploids. They have generally a higher number of flowering stems with conspicuously larger, deeper coloured flowers that are longer lasting compared to their diploid counterparts. Fertility is about 80–90%.

An important attribute of the tetra-snapdragons is the strong 'triploid barrier' (0.24% triploids after 4x × 2x crosses) and thus the diploid and tetraploid types can be grown together. This property together with other useful attributes, enables raising commercially exploitable fertile, true-breeding, vigorous tropicalized tetra-snapdragons in different colours. Sufficient foundation seed has been already raised (Mahal, 1972).

Verbenas. Four free flowering hybrid verbena cultivars have been evolved by hybridizing *V. tenuisecta* and *V. hybrida.* The former is a hardy, less-colourful, small-flowered species which grows almost throughout the year and is used as ground cover. The latter is an annual highly showy, large-flowered bedding species. The hybrid types obtained after repeated back-crossing are summer-hardy, with genes that confer heat resistance. They have matting habit with reasonably large but highly floriferous character. The hybrids have genic male sterility and normally do not set seed rendering them highly floriferous and free-flowering. It has been possible to extend the blooming period because of male sterility. These verbenas are excellent both as ground cover for rockeries and as bedding types. The hybrids can be propagated vegetatively (Arora, 1972; Khoshoo, 1979).

Amaranthus. 'Amar Shola', a hybrid amaranth, is totally a new ornamental with very appealing maroon-coloured beaded, erect inflorescence and represents a selection from a segregating progeny from a cross within *Amaranthus*

caudatus complex involving a grain type and an ornamental type (Pal, 1970).

Involving the available 'germplasm' of *Amaranthus tricolor* complex in a systematic hybridization and selection programme eight cultivars have been developed namely, 'Amar Kiran', 'Amar Poet', 'Amar Prithu', 'Amar Parvati', 'Amar Suikiran', 'Amar Tirang', 'Amar Raktabh' and 'Amar Mosaic'. These represent various combinations of leaf shape and colour and are entirely new to floriculture trade. Foundation seed of six of these has been sold to three well known floriculture firms of India for multiplication and commercialization. A tetraploid cultivar ('Amar Tetra') was evolved through colchiploidy. It is very attractive with broader, thicker and brighter coloured leaves compared to the corresponding diploid (Pal, unpublished).

Marigold. Marigold is one of the most important cut-flowers in India being used both for religious and decorative purposes. Complete technology for raising F_1 triploid hybrid (including maintenance of male sterile line) through the use of male sterile African diploid marigolds (*Tegetes erecta*) and male fertile French tetraploid marigolds (*T. patula*) has been worked out up to pilot scale. The F_1 hybrids developed are dwarf, highly floriferous and free flowering (due to sterility) with golden yellow heads giving nearby 1.5 times more flowers by weight per unit area (Jalil *et al.*, 1974; Khoshoo, 1979).

Amaryllis. The most common cultivars of this important cut flower, are diploids and some are tetraploids. To combine the heterotic effect of hybridization and gigantism associated with polyploidy, a number of triploid hybrids have been raised. These have given consistently excellent performance because of higher number of larger, ruffled, intense coloured and longer-lasting flowers per spike. The stock of these types, eg. cv. 'Kiran', has already been released. One tetraploid ('Samarat') and a semidouble ('Jyoti') have also been released (Fig. 2) (Narain, 1972).

Gladiolus. While in world's market a number of excellent gladiolus varieties are available, these however are unsuitable for the North Indian plains as the corms get damaged at higher temperature and humidity. Through systematic hybridization involving *Gladiolus* 'Friendship' (2n=60) with *G. tristis* (2n = 30) eight new triploid (2n = 45) cultivars namely 'Manmohan', 'Manohar', 'Mukta', 'Manhar', 'Manisha', 'Mohini', 'Triloki' and 'Sanykta', were evolved. Two aneuploid cultivars 'Archana' (2n=60) and 'Arun' (2n=67) were evolved through hybridization between *G. psittacinus* 'Sylvia' (2n=75) as the female parent with gladiolus 'Friendship' (2n=60) and gladiolus 'Fancy' (2n=60) as male parents respectively. All these cultivars have been released, and are getting popular in the cut flower trade.

Erythrina resuparelii. It is new beautiful perennial shrubby type evolved through hybridization between *E. resupinata* Roxb.—an indigenous unique

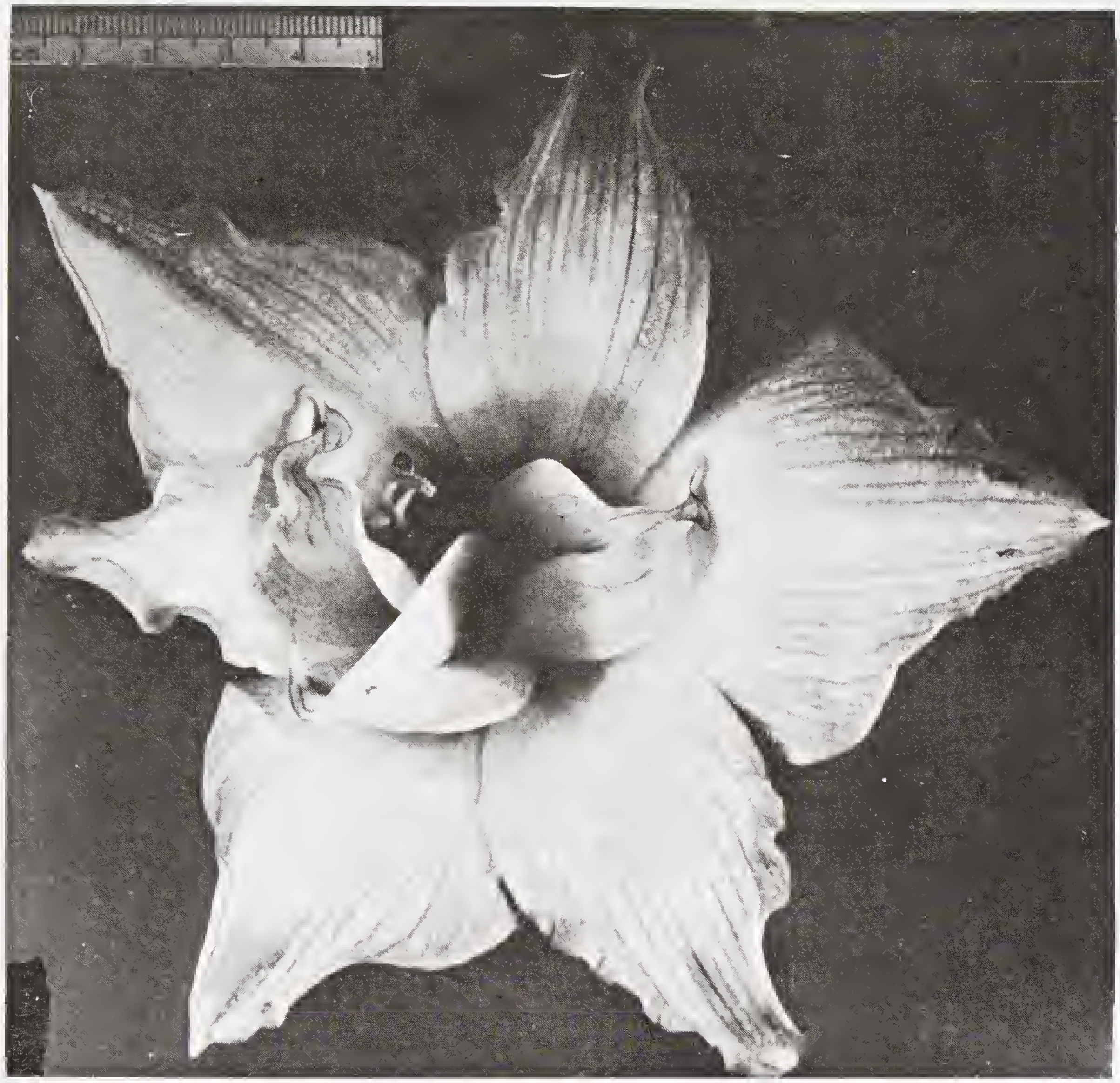

Fig. 2. *Amaryllis* cv 'Jyoti'

species of the genus growing in tarai regions of U.P. and Bihar, and *E. variegata* Linn. var. *orientalia* (Jalil *et al*., 1982).

Mutations

Induced mutations. Mutation breeding has been used to produce novelties in flower colour/type and foliage of vegetatively propagated ornamental plants. Fifty five gamma-rays (1 to 5 Kr)-induced somatic mutations in *Bougainvillea* (2), *Chrysanthemum* (34), *Lantana depressa* (2), Perennial *Portulaca* (6), *Rosa* (9), and *Tuberose* (2) have been established as new cultivars and released. The details are as follows:

Ornamental	Mutant	Characters	Parent
Bougainvillea	'Arjuna'	Variegated leaves	'Partha'
	B. pallavi	Variegated leaves	'Rosevilles' 'Delight'
Chrysanthemum	'Alankar'	Spanish orange flower	'D-5'
	'Anamika'	Light-reddish	'E-13'
	'Basanthi'	Yellow	'E-13'
	'Hemanti'	Chinese yellow	'Megami'
	'Cosmonaut'	Anemone type flower	'Nimrod'
	'Kapish'	Brownish flower	'E-13'
	'Lohit'	Dark-reddish	'E-13'
	'Man Bhawan'	Bicoloured (yellow and red)	'Flirt'
	'Sheela'	Canary yellow	'Himani'
	'Asha'	Creamish yellow	'Hope'
	'Ashankit'	Bright mauve, semi-quilled fringed florets	Undaunted
	'Aruna'	Dark-reddish	'Ashankit'
	'Basant'	Yellow heads	'Paul'
	'Gairik'	Salmon-light, almost incurved florets	'Belur Math'
	'Kansyaa'	Bronze flowers-head	'Rose Day'
	'Kunchita'	Incurved ray florets	Undaunted
	'Jhalar'	Mauve, almost flat and fringed florets	Undaunted
	'Nirbhaya'	Lighter mauve flower	Undaunted
	'Nirbhik'	Lighter mauve, almost flat, fringed ray florets	Undaunted
	'Pingal'	Lovely tetracotta flower	'Pink casket'
	'Pitaka'	Yellow flower-heads	'Kansya'
	'Pitamer'	Yellow flower-heads	'Otome Zakura'
	'Purnima'	White flower-heads	'Otome Zakura'
	'Rohit'	Rhodonite red flower	'Kingsford Smith'
	'Shafali'	Light-reddish flower	Undaunted
	'Shukla'	White flower	'Mrs H. Gubby'
	'Shveta'	White, semi-quilled flower	'Fishtail'
	'Svarnim'	Light-brown flower	Undaunted
	'Tamra'	Intense coppery red	'Goldie'
	'Taruni'	Azalia pink flower	'Kingsford'
	'Talike'	Paint brush type florets	'M-24'
Lantana depressa	*L. depressa variegata*	Variegated leaves	*L. depressa*
	'Naharika'	Canary yellow flower	*L. depressa*
Perennial *Portulaca*	'Jhumka'	Dissected, obtuse petals	'Karana Pali'
	'Karana Pali'	Acutely tipped, dissected petals	P. *Portulaca*
	'Lalita'	More petals, upper half of petals turning white	'Vibhuti'
	'Mukta'	Incurved petals with white tips	P. *Portulaca*
	'Ratnam'	Profusely blooming, single flowers	P. *Portulaca*

	'Vibhuti'	Incurved flowers with white margin when temperature and humidity high	'Mukta'
Rosa	'Angara'	Dark-reddish flower	'Montezuma'
	'Sharada'	Almost white flower	'Queen Elizabeth'
	'Sukumari'	Almost white flower	'America's Junior Miss'
	'Tangerine Contempo'	Tangerine orange flower	'Contempo'
	'Yellow Contempo'	Empire yellow	'Contempo'
	'Pink Contempo'	Pink fower	'Contempo'
	'Curio'	Muth-flowered curious looking flower	'Imperator'
	'Twinkle'	Stripped (pink and red) flower	'Imperator'
	'Light Pink Prize'	Light-pink flower	'First Prize'
Tuberose	'Rajat Rekha'	Silvery white streaks along the middle of the blade	'Single-flowered Tuberose'
	'Svarna Rekha'	Golden yellow streaks along the margins of blade.	'Double-flowered Tuberose'

Spontaneous mutations. Spontaneous mutations were detected in the rose cultivars namely 'Elizabeth of Glamis', 'Cri Cri' and 'Summer Holiday', Bud sports were isolated, multiplied and resulted in the following new cultivars.

'Salmon Beauty' : Salmon coloured bud sport of 'Elizabeth of Hlaims'
'Clg. Cri Cri' : Climbing bud sport of 'Cri Cri'.
'Winter Holiday' : Rose pink bud sports of 'Summer Holiday'.

Biochemical Studies

Biochemical analysis of bract mutations in bougainvilleas. Bougainvilleas have a wide range of bract colours ranging from white to various shades of yellow, orange, magenta, red, purple and violet and are considered to have arisen as a result of mutations (spontaneous hybridization and/or bud sports) among various forms of three basal species. An interesting method for the biochemical analysis of bract pigments involving paper electrophoresis was developed and bracts of more than 100 cultivars were analysed so as to evaluate this character as a possible chemotaxonomic parameter for the identification of cultivars on one hand and to study the genetics of colour on the other. The results have indicated that:

(i) The bract colour in *Bougainvillea* is determined by the relative qualitative and quantitative combination of betalain i.e. betacyanin, and betaxanthin pigments and all the colour forms can be explained on this basis.

(ii) The basal species and the three hybrid groups have a definite pattern of bract pigments and that can act as a chemotaxonomic marker for the identification of basal species and hybrid groups. Interspecific hybridization

brings about an interaction of two disparate genomes by bringing them together in an entirely different genetical environment. This is the basis of different novel colour forms (Kochar and Ohri, 1977).

(iii) Mutations seem to bring about a partial or complete loss of betacyanins and/or quantitative or qualitative increase in betaxanthin production.

(iv) A particular expression of bract pigments is also influenced by the external and internal factors like light and temperature by which the genes responsible for the synthesis of these pigments can be repressed or derepressed. For example, light has been found to enhance the synthesis of betacyanin and some bands of betacyanin disappeared when the newly formed bracts were put in darkness. The nature of some of the cultivars like 'Mary Palmer' can be explained on this basis (Kochar *et al.*, 1979).

Studies on the action of light on the biosynthesis of betacyanin pigments in the seedlings of Amaranthus caudatus. The action of light in the induction of betacyanin pigments were studied. The induction experiments performed with different light qualities showed that the inductive light operates through phytochrome and through a blue/UV photoreceptor (Cryptochrome). A phytochrome dependent 'High Irradiance Reaction' (HIR) or the light absorption through photosynthetic pigments do not play any significant role. There is a specific interaction between the light effect mediated through phytochrome and cryptochrome in the sense that the degree of reversibility increased with increasing P_{fr} level during the induction period. The extent of the reversible response increased with the fluence rate during the induction period. Such type of interaction has been reported for the first time (Kochar *et al.*, 1981).

Some of the hormones like kinetin increased the biosynthesis of these pigments. Light and hormones behave independently in this respect (Kochar *et al.*, 1981).

PROPAGATION

Vegetative propagation (cutting and grafting) is the universal method of multiplication of ornamentals. Intermittent water mist, with or without rings and auxin treatments (Kher and Bhutani, 1979) has induced roots in cuttings of *Hibiscus rosa-sinensis* cv 'Alipore Beauty', *H. schizopetalus, Jasminum sambac, Callistemon lanceolatus, Nyctanthes arbor-tristis, Lagerstroemia lancasteri, Nerium indicum, Ficus decora, Dombeya natalensis, Juniperus chinensis* and tip cutting of *Bougainvillea* cv. 'Garnet Glory'.

Gladiolus. Gladiolus is multiplied by corms. Sharga and Basario (1976) observed that the potentiality of corm is directly proportional to its size in respect of number of corm/cormels produced per plant besides quality of spike in case of

G. psittacinus 'Sylvia'. They further observed that mechanical removal of sprouts in succession during storage greatly helped in augmenting number of corms and cormels produced per plant. However, the total weight of corms produced per plant remained unaffected. Sharga *et al.* (1978) found that the variant clipping of spikes at green bud, first bud, and last bud stage was most effective in restoring regeneration capability of corms and the response was in ascending order. There was qualitative improvement of smaller corms by way of many-fold increase in corms weight and diameter and quantitative improvement of larger corms by augmenting cormel production. Sharga *et al.* (1983) reported that clipping of spikes together with differential number of leaves was detrimental to the production of corm and cormlets beyond a reasonable limit. The corm diameter remained unaffected by retaining half of the total number of leaves and corm weight by retaining 2/3, whole and 3/4 number of leaves, in case of A (6–7 cm), B (4–5 cm) and C (1–2 cm) grade corms respectively.

So far, tissue culture has been most successfully applied for micropropagation of plants, particularly ornamentals. The morphogenetic studies with the accent on developing method of rapid propagation of the following ornamentals, ranging from herbaceous annuals to bulbous and woody perennials, have been successfully pursued at the NBRI. Orchids, namely *Vanda hybrida (Vanda* 'TMA' × *V. teres* Roxb.), *Rhynchostylis retusa* Bl., *Dendrobium chrysotoxum* Lindl., *D. transparents* Wall., *D. fimbriatum* Hook., *D. hybrid (D. fimbriatum* × *D. densiflorum* Wall.), *D. chrysanthema* Wall. ex Lindl., *Cymbidium* D. Don, *C. mastersii* Griff. *Paphiopedillum fairieanum* (Lindl.) Pfitz., *Bougainvillea glabra* Choisy 'Magnifica', *B.* × *buttiana* Holttum and Standley 'Scarlet Queen Variegated' and *Bougainvillea* hybrid ('Tetra Mrs McCleans' × 'Dr B.P. Pal'), *Rosa hybrida* L. 'Super Star'; *Petunia hybrida* Hort. ex. Willd. double and single; *Chrysanthemum morifolium* Ramat, 'Qtome Zakura', 'Pandhari Revdi', 'Turbulent' and 'Birbal Sahni', *Gaillardia pulchella* Fouger, *Amaryllis* hybrid, *Gladiolus psittacinus* hybrid; *Polianthes tuberosa* Linn., *Lilium longiflorum* Thunb. and *Peperomia obtusifolia* A. Dieter. (Chaturvedi, 1979; Chaturvedi *et al.*, 1982) have been successfully propagated through tissue culture.

Orchids. Mericloning of orchids as propounded by Morel (1964) is not practicable for monopodial orchids. Hence, an innovative method of mericloning without sacrificing the mother plant, was developed by inducing protocorm differentiation in excised tips of young roots and leaves of three commercially important monopodial orchids, viz. *Vanda hybrida, R. retusa* and *D. chrysotoxum* (Chaturvedi *et al.*, 1982). An enormous number of plantlets was produced from the proliferation of such protocorms within a period of three to four months (Fig. 3). Besides, shoot buds present at the base of a flower stalk of *P. fairieanum* and those at the nodes of *D. chrysanthema* were also used for mericloning. Seed callus of *D. chrysotoxum* was made to differentiate in to multiple

plantlets simply by withdrawing 2,4-dichlorophenoxyacetic acid from the medium. Whereas, the regenerative potentiality $\pm$ of seed callus of *D. fimbriatum*, which was apparently lost during prolonged subculture over three years, could be restored by incorporating the vitamin supplement in the basal medium. The *in vitro*-raised plantlets of a number of orchids were grown in pots.

Bougainvillea. The report of multiplication of *B. glabra* 'Magnifica' by shoot tip proliferation (Chaturvedi *et al.*, 1978) was the first for any woody ornamental. Special mention may be made of luxuriant shoot proliferation of *B.* × *buttiana* 'Scarlet Queen Variegated' and 100 per cent rooting of the *in vitro*-regenerated shoots of this difficult-to-root cultivar (Fig. 4). The *in vitro*-raised plants grew in soil and flowered normally.

Rose. A prolific multiplication of shoot apices and axillary buds of *R. hybrida* 'Super Star' was obtained *in vitro* provided the cultures were incubated at 20°C (Fig. 5). By a moderate estimation, about 2,500 potential plantlets could be produced from explant in one year.

Chrysanthemum. Shoot apices of *C. morifolium* 'Otome Zakura', 'Pandhari Revdi', and 'Birbal Sahni' were proliferated at a very fast rate, yielding an average of about 900 million plants from a single explant in one year.

Fig. 3. Proliferation of protocorms.

Fig. 4. *Bougainvillea* cv. 'Scarlet Queen' variegated *in vitro*.

Fig. 5. *Rosa* cv. 'Super Star' *in vitro.*

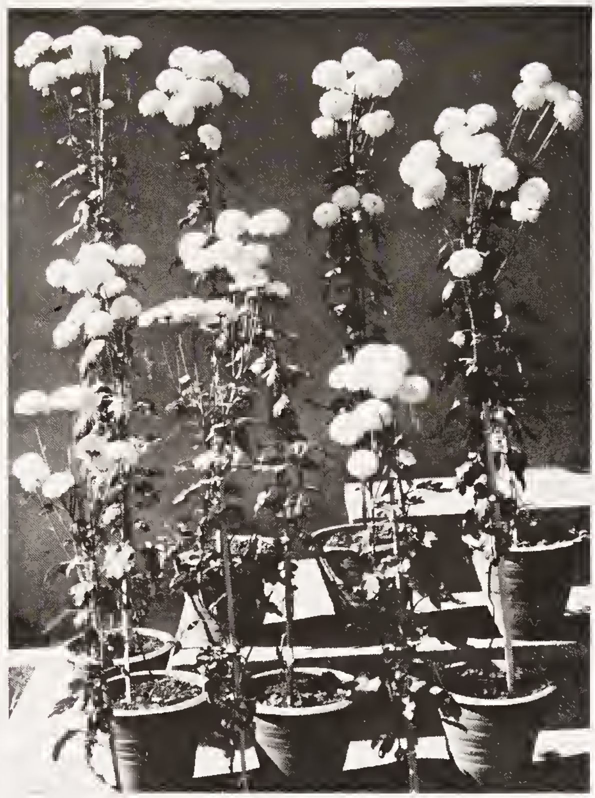

Fig. 6. *In vitro*-raised flowering plants of *Chrysanthemum morifolium.*

The *in vitro*-raised plants flowered true-to-type under field conditions (Fig. 6).

The season of collection of explants from the field-grown plants were decisive for their proliferation in the case of 'Birbal Sahni' while other cultivars were, more or less, ndifferent in this respect, thus, the shoot apices of 'Birbal Sahni' could be induced to proliferate only if they were collected from March to April and those obtained during rest of the year produced only callus.

Bulbous Ornamentals. Amaryllis hybrid and *L. longiflorum* were multiplied by using segments of bulb-scales, *Gladiolus* by segments of inflorescence stalk and *P. tuberosa* by shoot apices. The bulblets differentiated on explants of bulb-scale and inflorescence stalk and off-shoots regenerated from a shoot tip were subcultured, proliferated and made to grow into plantlets. The rate of multiplication improved during successive years of subculture, which was remarkable particularly in the case of *P. tuberosa.* The *in vitro*-raised plants of *Amaryllis* were grown in soil where they flowered true-to-type after three years of their transplantation in soil. About 4,000 cloned plants could be produced from a single bulb-scale in one year.

AGRO-TECHNIQUES

Agro-techniques have been standardized to extend the blooming period, to improve the quality of flowers, multiplication of bulbs, miniculture and dehydration of flowers.

Amaryllis blooms only for six weeks under natural conditions. Two techniques were standardized to extend this period to eight months. One consists of raising the temperature by using an incandescent bulb 'ON' for 4–5 weeks for forcing the blooms while the other technique is delaying blooming by withholding water.

Slow multiplication or no natural multiplication of amaryllis bulbs is another problem which was solved by standardizing 'Notching' (Fig. 7) technique (Gupta and Kher, 1983). This technique also solved the problem of perpetuation of the highly improved 'Dutch Hybrid' cultivars which used to perish after flowering due to non-proliferation of bulbs in plains.

The problem of short blooming period of chrysanthemum was taken up and the photoperiodic response of 59 cultivars has been studied. The resultant data is useful for having programmed blooming in these varieties for six months instead of six weeks by manipulating photoperiod alone. Besides, the use of newly developed ecotypes, as per schedule standardized at the NBRI, enables one to obtain blooms all the year round without environment control. The 'Miniculture' technique standardized at NBRI is yet another example of how pot culture of chrysanthemum can be made cheaper, easier and aesthetically rewarding and commercially more profitable. In *Chrysanthemum* (Kher, 1975) and *Gladiolus* complete package of cultural practices have been standardized for pot-culture cut flower and bulb production.

In India, pioneering work has been done at the NBRI on standardizing dehydration technique for preservation of natural shape and colour of flowers and foliage in several ornamental species (Kher and Bhutani, 1979).

PLANT PROTECTION

Several viruses infect ornamental plants (Singh and Srivastava, 1981; Aslam, 1984). Investigations confirmed the presence of complex infections (Hollyhock Yellow Mosaic Virus + Tobacco Leaf Curl) in *Althea rosea* (Srivastava *et al.*, 1977), Chrysanthemum Stunt and Chrysanthemum Mottle Viroids, Chrysanthemum Mosaic and Tomato Aspermy Virus in *Chrysanthemum morifolium* (Singh, 1970). Petunia Mosaic Virus in *Petunia hybrida* (Raizada *et al.*, 1984). Severe mosaic in *Vaccaria pyramidata* (Srivastava *et al.*, 1981) and Zinnia Yellow Net (Srivastava *et al.*, 1977) and Yellow Vein Banding Viruses in *Zinnia elegans*, Gladiolus Tip Necrosis and Gladiolus Mosaic Viruses in *Gladiolus*

Fig. 7. *Amaryllis*—rapid multiplication by notching.

psittacinus, Amaryllis Ring Spot and Amaryllis Mosaic Virus in *Amaryllis belladonna* (Singh *et al.*, 1983) and Periwinkle Chlorotic Stunt Virus in *Catharanthus roseus* (Zaidi *et al.*, 1978).

The investigations were mainly confined to identification and characterization of viruses based on UV spectrum, electron microscopy,

serological and biological methods. The data confirmed that these viruses mainly belong to Ilar, Nepo, Poty, Tobamo, Carla, Clostero, Rhabdo and Tomato Spotted Wilt groups on the basis of particle morphology, ELISA tests and molecular weight of protein subunits (Aslam, 1984).

Studies on host-virus interaction disclosed that virus mainly alters proteins (amino acids) and nucleic acid metabolism.

Virus-free plantlets of gladiolus, narcissus and petunia were obtained with the help of tissue-culture techniques combined with chemotherapy especially with the use of virazole and dyes (Aminuddin *et al.*, 1986).

Epidemiological studies were carried out to determine the key role of weeds especially *Datura metel, Nicotiana plumbaginifolia, Physalis minima, Solanum nigrum* and *Solanum xanthocarpum* in the occurrence of virus in ornamental plants. Weeds are an excellent reservoir/alternate host of viruses and vectors (Ram Krishna, 1980). *Ageratum conyzoides* plays an important role in the infection cycle and spread of Zinnia Yellow-Net disease agent (Srivastava *et al.*, 1977).

Results have indicated that the integrated plan of management to check weeds, vectors and alternate hosts will help to have virus-free plants propagated from virus-clean propagules produced by manipulated techniques coupled with heat therapy and use of chemotherapeutants in the case of *Zinnia, Gladiolus, Chrysanthemum, Petunia, Gerbera* and *Narcissus* (Aminuddin *et al.*, 1985).

The various cultivars of *Chrysanthemum morifolium* are infected with fungal pathogens showing ‘wilt’, ‘blight’, ‘leaf-spot’. The main causal agents are *Phyllosticta chrysanthemi, Cercospora chrysanthemi, Septoria obesa, Septoria chrysanthemella* and *Fusarium oxysporum.*

Dithane M-45 at 400 and 600 ppm causes 100% inhibition of *Fusarium oxysporum.* Soil application of Dithane M-45 at 18.75 kg/ha can effectively control the wilt disease in the nursery stage.

Besides *Chrysanthemum,* several important ornamental and economically important plants were surveyed for the fungal diseases, viz. ferns, *Araucaria bidwilli, Agathis robusta* and *Simmondsia chinensis* are infected with different species of *Septoria, Phyllosticta, Alternaria, Mycosphaerella, Colletotrichum gloeosporioides, Botryodiploida theobromae* and *Alternaria* respectively.

FLOWER SHOWS

For creating interest and raising the standard of floriculture, the NBRI organises house plants, chrysanthemum and coleus, rose and gladiolus and bougainvillea shows and exhibitions. Exhibitors from all over the country bring their exhibits and compete in the flower shows. On these occasions the

Institute also displays R & D work of floriculture. The standard of the NBRI flower shows had been very high. The interaction with the cross section of the society had helped in the promotion of floriculture.

SUMMARY

The Institute has undertaken a major project on ornamentals. Using different approaches new varieties of important ornamentals have been evolved. The genetic base for subsequent directed-breeding programme has been established and characterized. Tissue-culture techniques for the preservation and multiplication of well-known varieties of ornamentals have been worked out. The biochemical reasons for colouration in some have been identified. A systematic study of viral and other pathogens has provided information on control of diseases of ornamental plants. The efforts also include introduction of new ornamentals after proper research and standardization of agro-techniques that solve age-old problems in some ornamental crops.

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4

Rose

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> "Oh no man knows
> Through what wild centuries
> Roves back the rose."
> *Walter de la Mare*

THIS familiar quotation has a special relevance when we write of roses in India. Dr B.P. Pal, quoting Bassity, refers to a charming Hindu legend, according to which, when Vishnu came down to earth and was bathing in a pool, a lotus blossom opened, out of which stepped Brahma, who, pointing to the lotus, claimed it to be the most beautiful flower on earth. Vishnu, while agreeing to its beauty, invited Brahma to his own Paradise, Vaikunth, where he pointed to a rose bush in a beautiful bower–there was just one flower, pale as the moon with perfume so sweet that Brahma bowed his head and admitted, 'This is the fairest flower that grows'. There can be no doubt that roses would have been well known in ancient India as several wild species are to be found in the Himalayas, and Vaikunth, at least according to one version, is Mount Meru, a mountain to the north of the Himalayas. The poets of ancient India, especially Kalidasa, circa AD 400 were undoubtedly fascinated by the scenery of the Himalayas and the beauty of the wild rose would surely not have escaped notice.

But when did rose cultivation begin in the plains of India? To this there is no clear answer. B.S. Bhatcharji, the pioneering Indian rose hybridizer with more than a trace of patriotic fervour, says that *Rosa chinensis* (or the China rose) should really be *Rosa indica semperflorens*, relying on the observations in Dr Jules Hoffman's work on roses published in Germany (English translation, 1905). He also disputes the fairly common assertion that the original name of Bengal rose or *Rosa bengalensis*, used for the early rose introductions from China, was a mistake arising from the fact that roses were brought to England and France by the ships of the

East India Company, which passed through Calcutta. Quoting Dr Hoffman further, he asks, 'Where were the ships of the East India Company when roses from India and Persia reached the Greek and Roman Empires? In other words, Bhatcharji implies that roses from India had reached Europe much before the days of the East India Company.

Without entering into this controversy, it is clear that certain types of roses were cultivated in India for many centuries. Even an authority like Firminger refers to the common China, 'Musk' and the 'Bussorah' ('Damask') rose as being cultivated in India prior to the introduction of various types of Tea, Noisette, and Hybrid Perpetual roses from Europe towards the end of nineteenth century. But, as Dr Pal points out, authentic information on rose growing in India is available only from the days of the Mughals.

INDIAN SPECIES

Several rose species, as stated earlier, grow in the Himalayas. Among these are *R. webbiana*, characteristic of the dry Kashmir and Western Himalayan belt, and the moisture-loving *R. gigantea*, which is found in the extreme eastern portion of the range, especially in Sikkim, Meghalaya, Manipur and contiguous areas of Burma and South-West China. The beauty of *R. gigantea* is described in ecstatic terms by the well-known authority Graham Thomas, who refers to the tremendous stature of the plant (12 m or more), the strong shoots and the hooked prickles with large elegant drooping leaves and giant lemon-white silky flowers 12.5 cm across. This rose is of great interest as it is one of the parents of the Tea rose, probably contributing to that class the pale yellow flavonoid pigments and the long elegant petals. In passing, we may note that this goes to support Bhatcharji's contention referred to earlier that Tea roses are as much Indian as they are Chinese. More recently the species was used to raise a series of climbers adapted to the Australian climate by Alitair Clarke of Melbourne—'Nancy Hayward', 'Lorraine Lee', etc.

Other interesting wild roses of the Himalayas are two members of the Musk rose complex *R. brunonii* (is this the white rose of the Vishnu-Brahma legend?) found in Nepal and the Garhwal areas of the Himalayas, and *Rosa longicuspis*, found in the Khasia and Mishmi Hills of eastern India. Both of these giant climbers have that most attractive characteristic of the Musk rose—the capacity to waft fragrance in the air. The third member of the Musk roses is the southern *R. leschinaultiana* (*R. moschata leschinaultiana)* which is found in the Nilgiri and Palani Hills of south India. Other wild roses found in the Himalayas include the pink *R. macrophylla*, the lilac-pink *R. webbiana,* as well as the four-petal white-flower *R. serica*. Some historically

important roses are also semi-naturalized, *R. foetida*, the golden yellow rose of Iran found in the similar climatic belt of Kashmir as also the Afghan *R. ecae*, with bright yellow flowers apparently used as hedges around Kargil in Ladakh.

Perhaps the most important of India's wild roses is the tropical *R. clinophylla (R. involucrata)* which is described as growing throughout the Indian plains, especially in the plains of Bengal, near streams and marshy places. If crosses could be made w th this white-flower semi-climbing rose which is clearly well adapted for warm climates we would have made a tremendous advance in rose breeding in India.

No doubt the wild roses of the country are the most authentic of Indian roses, but the following description will concentrate on roses hybridized in India.

PIONEER HYBRIDIZERS AND THEIR ROSES

The most prominent of early Indian hybridizers is undoubtedly B.S. Bhatcharji, owner of the rose nursery P. Bhatcharji & Sons; sadly no more in existence. In fact it is difficult to exaggerate the importance of the work done by B.S. Bhatcharji and his sons, S.M. Bhatcharji and A.M. Bhatcharji. The Bhatcharjis were probably not India's first hybridizers; that honour belongs to one B.K. Roy Chowdhary, a nurseryman in the Santhal Parganas, who in 1935 raised the variety 'Dr S.D. Mookerji'.

But during 1956–1966 to 1967, the Bhatcharjis raised several hundred rose varieties (Hybrid Teas, Floribundas, and a few climbers) out of which 125 are listed in Dr B.P. Pal's book entitled, *The Rose in India.* There is, however, a certain discrepancy in the dates, as Shri B.S. Bhatcharji in the Preface to the second edition of his book, *Rose Growing in the Tropics* published in 1959, states that his attempts to raise new roses suitable for the tropics are being continued for nearly a quarter century. Undoubtedly, he must have been prominent at an earlier date for, as far back as 1933 a rose 'B.S. Bhatcharji' was introduced by the famous firm, A. Dickson & Sons of the U.K.

Numbers apart, what is most significant is that the elder Bhatcharji was perhaps the first Indian to recognize that we require a separate line for breeding in the warm tropical climate,· and pursued this objective with sustained vigour. Readers will be interested to know that roses raised by Bhatcharjis were exhibited as 'Roses from India' at the 1958 International Rose Conference in London; and one of their roses 'Sister Nivedita' was catalogued by the English firm, Frank Cant & Sons in 1962 or 1963. In fact he had the vision to send a large number of varieties for trial during the late fifties to Frank Cant & Co., U.K., who placed quite a number

of these varieties in the Royal National Rose Society Trial Grounds. Sadly, but as could be expected, these roses selected for good performance in the warm climate did not fare well under English conditions. In a way confirming the validity of the concept that a rose selected for good performance in the warmer areas, could hardly be expected to perform well in a cool moist climate, though many appeared promising whenever the weather there was favourable. The point is to this day of great relevance, for Indian rose fanciers still feel that new rose varieties imported from the West are virtually the only roses worth trying out, forgetting that the converse is equally correct.

"Today the foreign researchers are creating winter hardy roses to cater to the rose fanciers of the cold zones. Such varieties produce a wealth of blooms in such a climate which is cooler in temperature" (during summer) "than the winter in even most parts of North India, not to speak of South India. The great majority of such winter hardy roses are very unhappy in tropical warmth" write the Bhatcharjis in the introduction to their 1963 catalogue.

As Dr B.P. Pal points out in his recent book, 'Survey on Rose Breeding in India', there is unfortunately not much information available on the parentages of the Bhatcharji roses, nor the various types used by them in their endeavour to breed warm climate roses. But, having grown a fairly large number of their productions, we may speculate that judging by appearances, many of the older Hybrid Perpetuals were used in their breeding programme, in a search for fulness and stiff stems; some of the *chinensis* varieties, including 'Cecile Brunner' (the influence of 'Cecile Brunner' is quite evident in varieties like 'Muktadhara', a satin pink Floribunda, 'Toohin' white Floribunda); and some of the Tea roses. If we look at one of Bhatcharji's famous roses, the apricot Hybrid Tea 'Raja Ram Mohan Roy', and his later production, 'Tilottama', in the same colour range, the influence of the Tea roses of the 'Lady Hillingdon' type is apparent.

Among the well known Bhatcharji roses which are still available are the red Hybrid Tea, 'Heart Throb', with huge but elegant blooms of the richest crimson scarlet and fragrance to match, 'Raja Ram Mohan Roy', with blooms in lovely shades of bronze apricot on a strong bush, and Floribunda, 'Pandit-Nehru', with medium-size blooms in the orange scarlet range. Other popular Bhatcharji roses include the very fragrant red Hybrid Tea, 'Sugandha' which is pictured in the stamp released on the Rose Day recently by the Posts and Telegraphs Department as also the dark black-red Hybrid Tea, 'Kalima'.

In fact B.K. Roy Chowdary and A.K. Roy Chowdary are apparently the only other two prominent rose-breeders who raised new roses in the period 1960 or earlier.

ROSE BREEDING IN THE SIXTIES

With the decline of the Bhatcharjis by the beginning of 1960s a fresh impetus was given to rose breeding on what may be called a three-pronged front: by amateurs; by Government research institutions; and by professional nurserymen.

Dr B.P. Pal, the then Director of IARI, decided to take up rose-breeding at a personal level, towards the end of fifties. Because of which, apart from his personal interests, Dr Pal was able to provide a very powerful stimulus to the production of new rose varieties by the IARI. Rose-breeding being what it is, partly science and partly art, readers can easily understand what a difference it would make if the head of a government research institution is himself an imaginative rose breeder.

About the same time work on rose breeding at the nurseryman level started with the emergence of Sri G. Kasturirangan, owner of the renowned firm of K.S.G. Sons, Bangalore. In nutshell, the decade saw great progress on all three fronts.

In a series of five articles published in the *Indian Rose Annuals* of 1980, 1982, 1983 and 1985 (yet to be printed), Dr Pal has furnished a full account of his work in rose breeding. In his latest article scheduled for publication in the forthcoming *Indian Rose Annual*, he states that his rose breeding has not been based on any long-term programme. “My modest aim has been to try and evolve garden varieties suitable for climates like Delhi with extreme variations in climate”. The latter statement (perhaps understandably) hardly does justice to Dr Pal’s unique status as a rose breeder. Here, may be for the first time in the history of rose breeding, we have an eminent scientist with the highest qualifications in Genetics and Plant Breeding, with decades of practical experience in wheat breeding, and an equally long fascination with rose growing, involving himself with breeding roses as an amateur. But. . . there is yet a third factor–the artist’s sensitivity to form and colour which was simultaneously brought to bear on his work.

In his earliest work, Dr Pal started with open-pollinated seeds of the popular variety, ‘Gruss en Teplitz’ among the seedlings was a crimson Floribunda with fragrant flowers which was released as ‘Rose Sherbet’. A little later, in 1962, came the recognized pink Floribunda, ‘Delhi Princess’, which exhibits exceptional vigour and bears cerise red to warm pink flowers in great profusion. This variety has been extensively used by the IARI in its plant-breeding programme; in raising the dark red ‘Bhim’ and the Chinese yellow Hybrid Tea ‘Vasanth’.

One of the earliest Hybrid Teas raised by Dr Pal was the white ‘Dr Homi

Bhabha', a seedling of 'Virgo' (1967), and to this day it remains perhaps the best white Indian-raised Hybrid Tea. Among the other Hybrid Teas raised during the sixties may be mentioned the lovely 'Kanakangi', a seedling of 'Mme. Charles Sauvage', which attracts the eye with its rich shades of apricot yellow; the creamy yellow 'Poornima', a seedling of 'Farnand Arles', with extra long buds of exquisite form came in 1971, and the lovely dark red 'Mechak', a seedling of 'Samurai' in 1977. Other H.T. raised during the seventies include the pink blend 'Hasina' ('Youkisan' × 'Balinese'), the red 'Lalima' ('Picture' × 'Jour d' Ete'), the orange scarlet 'Nayika' (1975), 'Raat Ki Rani' dark red, apparently a sister seedling of 'Mechak'; 'Raja of Nalagarh', orange scarlet ('Samurai' × 'Montezuma'), the pink blend 'Rampa Pal', and the orange scarlet 'Ranjana' ('Sabine' × unknown), as well as the bicolour 'Surkhab'.

Among the Floribundas, apart from 'Delhi Princess', mentioned earlier, pride of place should be given to the golden orange red 'Banjaran' (1969), perhaps the most popular of Indian-raised roses and one which has performed well in trials abroad. During the seventies, some of the outstanding Floribundas raised include the orange scarlet 'Sailoz Mookerji' (1973), the pink blend 'Chitchor' (1972), the light yellow with pink 'Madhura' ('Kiss of Fire' × 'Goudvlinder'), and the orange vermilion 'Suryakiran' ('Orangeade' seedling).

During the eighties there was in a way, a slight shift of emphasis from pastel pinks to seedlings in shades of salmon, lilac, apricot orange, and dark red. Among the varieties used by Dr Pal in this latest phase of his work have been the reputed florist's rose, 'Sonia', the lilac Hybrid Tea 'Lady X', the bicolour Hybrid Tea, 'Granada', the apricot 'Chantre', as well as his favourite seed parents of earlier years, 'Sabine', 'Kiss of Fire', and 'Samurai'.

Among the 'Sonia' seedlings is 'Divaswapna' (1981), a shimmering blend of silvery pink and white which has inherited the beautiful reflexing form of the seed parent; and the elegant salmon 'Apsara', which may prove suitable for cut flowers as the plants are vigorous and floriferous; and the porcelain pink 'Aravalli Princess' (1983), with high-centred blooms that unfurl slowly.

'Granada' has been used to produce the Hybrid Tea, 'Indian Princess' (1980) ('Super Star' × 'Granada') with a very interesting colour ranging from light red on the outer petals to carmine with silvery edge on the inside; as well as the lovely lilac pink 'Akash Sundari' ('Granada' × 'Lady X').

Using 'Chantre', has come the glorious 'Golden Afternoon' (1980), which is rich coppery orange on the outside and golden apricot on the inside, with a delicious spicy fragrance. Probably his latest Hybrid Tea in this colour range, 'Eastern Princess' (1984), which is orange coral with a gold base, also derives its colour from 'Chantre'.

Seedlings of 'Sabine' include the geranium lake 'Nishada' (1982) ('Sabine' × 'Anvil Sparks'), bearing massive, shapely and intensely fragrant blooms, and the glowing pink Hybrid Tea 'Sandeepini'.

Using 'Samurai', Dr Pal has raised Dr R.R. Pal,a Hybrid Tea (1983) which bears huge flowers on strong upright stems ranging in colour from deep rose red to dark velvety red, 'Lal makhmal', a Hybrid Tea, again dark velvet red, but this time with a hint of ebony. The latest in this series of red roses is the blackish velvet crimson 'Dilruba', also a Hybrid Tea (1984), with high centred very fragrant blooms, and 'Ashirwad', a Hybrid Tea (1984), a bright red with golden based petals.

It is difficult to be exhaustive while dealing with the work of as prolific a rose breeder as Dr Pal with many more to come. The spectrum of roses already raised by him are his brain behind the scientist's hand but selected by the artist's eye, will act as the building block for the rose breeders of the future.

Taking up the work done at the IARI, we may note that the accent on hybridization is on evolving new cultivars for export of cut-blooms; disease-resistant garden roses, and cultivars with high essential oil content.

The earliest rose breeders at the IARI were V. Swarup, R.S. Malik, and A.P. Singh. Thereafter, Dr B. Chaudhury headed the Division of Floriculture followed by Dr U.S. Kaicker. Work at the Institute started in 1956, and among the earliest varieties evolved were 'Pusa Sonia', a golden yellow Hybrid Tea, seedling of 'McGredy's Yellow'; 'Himangini', an ivory white Floribunda, seedling of 'Saratoga', and 'Suryodaya', an orange Floribunda seedling of 'Orangeade', in 1968. Thereafter, considerable progress has been made towards attaining the objectives of the Institute's rose-breeding programme.

In its rose-breeding programme the IARI has laid great emphasis on Dr Pal's Floribundas and Hybrid Teas, 'Delhi Princess' which appears in the parentages of no less than five Hybrid Teas raised, 'Bhim' 1970 ('Charles Mallerin' × 'Delhi Princess'), with very full scarlet red blooms and is considered to be one of the best red roses to be evolved in India; 'Charugandha' 1972 ('Delhi Princess' × 'Eiffel Tower'), another crimson red Hybrid Tea; 'Raj Kumari' 1975 ('Charles Mallerin' × 'Delhi Princess'), Hybrid Tea in fuschia pink, 'Surabhi' 1975 ('Oklahoma' × 'Delhi Princess'), in shades of phlox pink. Two of the latest Hybrid Teas arising from the use of 'Delhi Princess' are the 'Vasanth' 1980 ('Sweet Afton' × 'Delhi Princess'), which bears Chinese yellow flowers edged with Neyron rose on a profuse blooming and vigorous bush, and 'Jawahar' 1980 ('Sweet Afton' × 'Delhi Princess'), one of the best white roses raised in India so far and quite appropriately named after India's first Prime Minister.

One of the most popular roses raised by the IARI is the phlox pink 'Mrinalini' 1972 ('Pink Parfait' × 'Christian Dior') with exceedingly well shaped blooms of exhibition form. Indeed this may be the best exhibition Hybrid Tea. In this colour created in India to date, another variety to be frequently used in the breeding programme is 'Sweet Afton'. Apart from 'Jawahar' and 'Vasanth', already mentioned, 'Sweet Afton' has been used in raising 'Anurag' 1980 ('Sweet Afton' × 'Gulzar'), fragrant variety in shades of pink. The porcelain rose 'Arjun', also a Hybrid Tea 1980 ('Blithe Spirit' × 'Montezuma') which bears beautifully shaped blooms on a very vigorous bush characterized by the ability to throw very strong (up to 1 m length) flowering shoots may prove suitable for cut-flowers. Mention should also be made of the Solferino purple 'Dr B.P. Pal' 1980, which bears extremely shapely blooms on a vigorous bush.

Several Floribunda roses have also been raised in the IARI. Here, 'Sea Pearl' and 'Orangeade' have been the favourite parents. A very interesting Floribunda is 'Mohini', 1970 ('Sea Pearl' × 'Shola'), in unique shades of chocolate, brown and orange. Other 'Sea Pearl' seedlings include 'Prema', 1970 ('Sea Pearl' × 'Shola') in soft pink; 'Dipshika' 1975, also with the same parentage, in Dutch vermilion; and 'Sindoor' 1980 ('Sea Pearl' × 'Suryodaya') in geranium lake. Perhaps the most popular of the IARI Floribundas is the purplish-mauve 'Nilambari', 1975 ('Blue Moon' × 'Africa Star'), a mass blooming of this variety in the Delhi winter is indeed the most attractive sight.

Apart from conventional rose breeding, the IARI has conducted detailed research on evolving new rose varieties by inducing mutations using gamma-ray treatment and chemical mutagen, EMS (Ethyl methane sulfonate). 'Abhisarika', 1975, an induced mutant of 'Kiss of Fire' using gamma irradiation is one of the five outstanding results. This rose has exquisitely shaped blooms of yellow with gaily-striped red, and is deservedly the most popular.

Shri G. Kasturirangan of K.S.G. Sons, Bangalore, as the owner of one of India's larger rose nurseries, has been chiefly responsible for ensuring that the tradition of rose breeding at the commercial rose nursery level, initiated by the Bhatcharjis, was continued. Apart from having access to a very large number of rose cultivars, Shri Kasturirangan had the most invaluable advantage as his father, the late Shri K.S. Gopalaswamiengar, India's one of the most outstanding breeders of ornamental plants. His bougainvilleas and crotons are still widely grown all over the country. A feature of the hybridization work done by Shri Kasturirangan is that he has contributed to all the rose types—Hybrid Teas, Floribundas, Polyanthas and Miniatures, by a prolific output of varieties numbering almost a hundred at present.

The better performing includes the bicolour, 'Srinivasa' 1969 ('Columbus Queen' × 'Charlotte Armstrong' × unknown), bearing very full high-centred blooms of red with white reverse. To this day it remains one of the best Indian-raised roses and is a regular prize winner at the rose shows. Following the same tradition is 'City of Panjim' 1972, Hybrid Tea ('Altesse' × 'Traviata'); one of his newer Hybrid Tea is 'Agnihotri' 1981, named in memory of a reputed Indian horticulturist, which bears massive blooms of rose red with lighter overtones.

Coming to the cluster-flowered class, Floribundas, we should note 'Devadasi', 1967 ('Lilli Marlene' × unknown), with dark-red-scented flowers, and the two uniquely-coloured Polyanthas, 'Bharani' and 'Nartaki'. 'Bharani' bears very deep magenta-purple with white eye flowers, and 'Nartaki', with dark lavender blooms and its yellow stamens adding to the beauty. In fact, 'Bharani' has recently been introduced in the U.K. under the name 'Baharmi' by Gandy's Roses.

Slightly later in the 1960s three more rose hybridizers made their appearance on the Indian scene. They are the late Raja Surender Singh of Nalagarh, Dr M.N. Hardikar, and myself.

Raja Surender Singh, in a short period between 1968 and 1971, hybridized no less than 13 varieties, employing seed parents such as 'Peace', and 'Clovelly'—his charming satin-pink 'Nazr-e-Nazar' a Hybrid Tea 1968 ('Clovelly' seedling) is perhaps the most prominent of these introductions, although the lilac Hybrid Tea, 'Yamini Krishnamurthy' 1969, also attracted considerable interest during its time.

Dr M.N. Hardikar, who started his work in 1967, is perhaps the pioneer of rose breeding in Western India. He describes how he was initiated into this activity by that great rosarian of Poona, R.S. Deshpande. Curiously, there is no information on whether Deshpande himself raised any new roses. Dr Hardikar's main objectives in rose breeding are to raise a really good crimson rose and a blend, both in the Hybrid Tea class. To this end he has raised several hundreds of seedlings out of which seven, up to 1980, were considered worthy of release. He has employed the varieties 'Scarlet Knight' ('Samurai'), 'Kronenbourg' and 'Festival Beauty' extensively in his work. Among this roses which deserve mention are 'First Rose Convention' a Hybrid Tea, 1971 ('Kronenbourg' × 'Helen Traubel') is dark red; 'Cynosure', also a Hybrid Tea, 1971 ('Scarlet Knight' × 'Festival Beauty') which is a striped rose with purple-pink stripes on red petals and very vigorous; and the fragrant pink 'Swami', a Hybrid Tea, 1971 also with the same parentage. More recently, Dr Hardikar has released 'Flying Tata', a Hybrid Tea, of bright crimson red with velvety sheen representing a further stage in his search for the ideal red rose. A new bicolour, pink blend, Hybrid

Tea, is proposed to be named by him in honour of Dr B.P. Pal.

My rose breeding work started in 1966. Probably because I was somewhat younger than the other hybridizers, whose work has been described so far. At the time of starting work, my objectives were comparatively more ambitious—with an emphasis on evolving a new line of heat-resistant roses with good vigour and long-lasting petal texture to cope with the scorching Indian sun. To this end four of the older types were selected. These were, the Tea roses; the Polyantha, 'Cecile Brunner'; the fragrant Bourbon hybrid, 'Rose Edward'; and the vigorous fragrant bush rose, 'Gruss en Teplitz'. These were used generally as seed parents and intercrossed with standard varieties, both Hybrid Teas and Floribundas, with the objective of combining the better qualities of each parent.

Using a pink Tea rose, probably 'Catherine Mermet', as the seed parent, I was able to raise a vigorous and healthy dwarf red Floribunda called 'First Offering' (in 1966–67 but introduced in 1973); which not only fared well in Hyderabad but performed outstandingly in the much more difficult climate of the Madras City. The projected line with 'Cecile Brunner' led nowhere in spite of more hundreds of crosses, though there are yet a few seedlings with other polyanthas showing promise.

Work with 'Rose Edward' proved to be even more difficult than with 'Cecile Brunner'. Almost all the seedlings retained the bright pink colour, but without' any fragrance. Also, the proneness to mildew of 'Rose Edward', was even more obvious in its progeny. Of a very large number of seedlings, only a cross into the yellow climber 'Golden Showers' produced anything worth notice. This was a giant climber with very full blooms of flesh pink and a tint of apricot blessed with a strong fragrance, but, unfortunately almost sterile. On one of the few occasions this seedling produced fertile pollen, it was crossed with a lilac Hybrid Tea, 'Sterling Silver', from which have appeared several seedlings in lovely shades of lilac purple. Work on this line is still in progress.

Work with 'Gruss en Teplitz' proved much easier probably because it is the only tetraploid rose of the four groups selected. An early success was the bright orange-red Floribunda 'Mahadev' 1975, which to this day is one of the brightest in this colour range. Another seedling with 'Gruss en Teplitz' intercrossed with the lilac roses 'Lake Como', 'Angel Face', and 'Lady X', led to the orchid-lavender 'Vanamali' 1978, which has been well received in various parts of India. Further work is now in progress with 'Vanamali' inter-crossed with some of the purple lilac seedlings raised from the 'Rose Edward' line described earlier. The 'Gruss en Teplitz' line also resulted in the pink-amber 'Amrapali', Floribunda 1979, and, the velvety magenta purple Hybrid Tea, 'Kanchi' 1970. 'Kanchi' has been doing well in a variety of climates.

Meanwhile, as soon as McGredy's first hand-painted-floribunda, 'Picasso' appeared in 1971, another objective was added to the list—to raise a good Hybrid Tea in the hand-painted range. After considerable effort came 'Priyatama', 1975, raised from a cross between the familiar Hybrid Tea, 'Inge Horstman' and 'Picasso'. In this, perhaps the first Hybrid Tea in the hand-painted strain, every flower is a different combination of white, pink and red. Introduction of this variety had to wait till 1981, since it was being tested in the US, where though the flower was almost always 'outstanding', the plant growth did not prove reliable in the heat of the American summers. A further cross with 'Priyatama' and the white Hybrid Tea 'Honor', has produced a very vigorous and shapely white-edged pink which is scheduled for release this year. Two of my other roses worth mention are the lilac pink 'Rajni', a Hybrid Tea, 1983, raised from a cross between 'Violaine' and 'Margaret Merrill', and the Floribunda 'Bhagmati', 1977. ('Charleston' × 'Roman Holiday') × ('Flamenco' × 'Gold Gleam') in shades of anturium scarlet with white reverse and golden eye. The latter combines unusual heat resistance and good petal texture in spite of not being raised from any of the four rose groups with which the search for heat-resistant roses began.

At the beginning of the seventies two more hybridizers, viz. Braham Datt of Nagpur, and Dr Y.K. Hande of Poona, started their work. Starting in 1970–71, Shri Braham Datt has been making several hundred cross-pollinations every year, with a variety of seed and pollen parents. After rigorous selection his first 'K.K. Thakur', a Hybrid Tea ('Daily Sketch' × 'Grand mere Jenny'), in shades of deep apricot was released only in 1980. Other more recent roses from this hybridizer are 'Don Nielsen', a Hybrid Tea, 1983 ('Inge Horstman' × 'Gold Topas'), a lovely pink and cream bicolour, and 'Pride of Nagpur', a Hybrid Tea, 1983 ('Grand Slam' × 'Tatjana') which bears very large dusky red flowers with good fragrance. Another of his outstanding unreleased variety is appropriately called 'Indian Festival', a Hybrid Tea ('Beauty of Festival' × 'Timothy Eaton' × 'Miss Ireland').

Almost simultaneously with Braham Datt, Dr Y.K. Hande, clearly brings his knowledge of agricultural science to bear on his hybridization. He has been concentrating on Hybrid Tea roses suitable for the climate of western Maharashtra, and his work is marked with great attention to detail an objective selection. Seed parents employed by him include 'Christian Dior', 'Swarthmore', 'Norita', 'Lady X' and 'Colorama'. Among the outstanding roses raised by him are the lustrous pearly-pink exhibition Hybrid Tea rose, 'Indian Pearl', 1983 ('Christian Dior' × 'Pascali'); the very fragrant, light-red Hybrid Tea 'Perfumer', 1983 ('Swarthmore' × 'Blue Moon'), which may fulfil the need for a fragrant cut-flower rose for western India;

and, the highly decorative bicolour Hybrid Tea ('Ajanta Caves', 1983 ('Coloramma' × 'Norita'), which bears eye-catching flowers of apricot-ivory-blended scarlet-red on the petal edges.

Among commercial rose growers, Mrs P.L. Airun of Anand Roses, Jaipur, J.P. Agarwal, the doyen of Indian rose nurserymen, Friends Rosery, Lucknow, and Arpi Thakur of Doon Valley Roses, Dehradun, have each made a contribution.

Mrs Airun's very first introduction 'Golden Days', 1976, Floribunda/Hybrid Tea type ('Whisky Mac' × 'Duet') which bears perfectly-shaped blooms of golden yellow edged red, has proved very popular. One of her more recent introductions is the Floribunda, 'Mahak', 1982 in shades of peach pink and apricot, with the added bonus of fragrance.

The Hybrid Tea, 'Kasturi Rangan' bears blooms with exciting shades of mauve with yellow base. To release a new rose at the age of 80 plus is a singular achievement indeed.

Arpi Thakur's 'Ajanta', a Hybrid Tea, 1978 ('Lady X' seedling × 'Memoriam'), in shades of mauve with a hint of green, has also attracted favourable notice.

The painstaking work on rose growing in the TISCO Nursery, Jamshedpur, by R.R. Karnad *et al.* also deserves mention. Among the several roses from this source are 'Pioneering Pilot', a Hybrid Tea, 1982, named to commemorate the historic flight by Sir J.R.D. Tata, which bears lovely flowers in deep purple red.

The pioneering work being done at the National Botanical Research Institute, Lucknow, by Dr M.N. Gupta *et al.* on colchicine-induced mutation should lead to some exciting introductions in the future.

Several other hybridizers, full details of whose work are not readily available, have also introduced one or more varieties each.

It will also be appropriate to emphasize that a great deal of important work has already been done by the Indian hybridizers with rudimentary facilities for research and without any incentives, financial or otherwise.

FUTURE OF INDIAN ROSES

Taking up the question of the future of Indian roses it should be noted that the popularity of rose growing in India on a long-term basis is directly linked to the production of suitable varieties for each of India's rose-growing zones. In a thought-provoking article the US hybridizer Dr John James has remarked:

(i) There is no universal modern rose, no matter how high the rating—one that will perform well everywhere.

(ii) This points to a fact that we ignore or choose not to recognize—roses are local or regional.

Arguing further, he points out that what are required are roses which grow well for home owners who are not avid gardeners. To drive home the point, he reports on the results of a survey in which he questioned a number of young people just starting out with their homes and gardens. On being asked whether they were going to plant roses, and if not, why not, the usual answers were; "Too much trouble". "Too expensive", "Don't live long", and "Don't always flower as expected".

This same point has been made much earlier by the doyen of Indian hybridizers, Bhatcharji, when he states that "rose growing is for the pleasure of having enough of good flowers on healthy plants under normal care".

The future of rose growing in India will be assured only when roses are grown not chiefly by enthusiasts as at present, but generally by all those interested in gardening If this is to happen, roses raised in India should be given a fair trial by rose growers who seem to be generally under the impression that what is raised in India cannot possibly be as good as what is imported from Europe or the US. Happily, this potentially disastrous misconception does not extend to our farmers who will hardly plant a wheat variety evolved in the US in preference to one raised in India, and recommended for being grown in that agroclimatic zone.

Apart from this mental block as regards Indian roses referred to above, two main factors stand in the way of Indian roses becoming more popular: (i) the absence of plant patent laws, which inhibit large-scale rose hybridization, there being no financial reward; (ii) the absence of trial grounds where Indian-raised varieties could be tested and their suitability determined for the various rose-growing areas in the country.

Taking up the latter point first, we may refer to the exhaustive "Rose-Calendar" prepared by Sunil Jolly, nurseryman from Dehradun, who has divided the country into 8 rose-growing zones. Ideally, we should have one trial ground at least in each of these zones, which, as Dr Pal suggests, could be one of the agricultural universities situated in the zone.

As regards plant patent legislation, it is curious that the Government of India should adopt an inhibited attitude to such an important piece of legislation, which will provide a tremendous incentive not only for the rose hybridizers, but for hybridizers of other horticultural plants as well. No valid objection can possibly be raised to plant patent legislation which covers vegetatively-propagated plants such as roses.

On the part of the Indian rose hybridizers what is required is "a bold response to the challenge of breeding better roses for India. To reiterate, what we really need is a separate line of breeding for the warm tropical

climate, and mere crosses between standard varieties evolved in the West, which have been selected for good performance in cold climates will not lead us very far". Indian rose hybridizers will have to ask themselves the question, why they still continue to raise new cultivars mainly by inter-crosses of imported rose varieties. Surely at least one of the parents in each cross could be the hybridizer's own introduction, selected for good performance in the Indian climate. Even the IARI seems to suffer from a needless inferiority complex about its own varieties—as these hardly ever figure as one of the parents in later introductions. Unless this trend is reversed the prospects of evolving a separate line of warm climate roses are indeed dim.

Before concluding, reference should be made to what is probably the most exciting prospect for rose breeding in India—that is, breeding with *Rosa clinophylla (R. involucrata).* As already stated this species is obviously well adapted to the warmth of the plains and also to water-logged conditions. Like many of the wild roses it is diploid—it is closely related to the black-spot-immune *R. bracteata*, and hopefully may carry the genes for black-spot resistance also. Since modern roses are tetraploid the difference in chromosome numbers will no doubt pose some initial problems but these could be overcome by standard procedures.

If rose hybridizers could raise hybrids with this rose species, a giant step forward would have been taken in evolving authentic Indian roses easily grown, not only in our own country, but throughout the tropical regions of the world, which have been denied the pleasure of good and easily grown roses so far. An adequate response to this challenge will ensure the future of Indian roses.

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5

Chrysanthemum

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CHRYSANTHEMUM is next only to rose in importance among the flower crops in the world. It is grown both for its aesthetic value and for commerce. Historically, Confucius, the great Chinese philosopher has in his writings mentioned chrysanthemum as early as in 500 BC making it one of the most ancient cultivated flowers of the world. After attaining a certain level of development in China chrysanthemum reached Japan via Korea more than a thousand years back. In Japan it underwent a great transformation resulting in evolution of a wide range of types varying from perfectly regular blooms to most irregular forms. It was proclaimed as the National Flower in that country by Emperor Uda in AD 910 and a sixteen-petalled 'Ichimonji' was adopted as the Imperial Crest during the 12th century (however, at present the National Flower is 'Cherry Blossom' but chrysanthemum is still regarded as symbol of royalty in Japan).

In England the popularity of chrysanthemum as exhibition flower is at its peak and as a commercial crop it occupies the second position in value of crop produced. In the United States it is the number one dollar-earner flower and the most reliable. Varieties that can be grown throughout the year have been evolved in that country. It is difficult to say with certainty when its culture began in India. Sant Gyaneshwar has mentioned it in His famous Marathi exposition of Gita "Gyaneshwari" written in AD 1290. The Hindi name *guldaudi* (meaning flower of Daud) suggests that it must have been grown during the Moghul Period in this country. However, most of the improved varieties grown in northern part of this country are of British, American or Australian origin. The yellow-flowered varieties grown in south, west and central India on field-scale seem to be old timers.

In India it has been recognized as one among the five important commercially potent flower crops by the All-India Co-ordinated Floriculture Improvement Project of the ICAR. In the different states of India it is grown

under different names, *guldaudi* in the Hindi belt, *chandramallika* in the eastern states, *samanti* in the southern states and *shevanti* in the western states. Chrysanthemum is versatile, it can be planted in the bed, cultured in the pot, used for garland-making and also as cut-flower for flower arrangement. Therefore, the modern techniques based on scientific research and by evolving more attractive cultivars, have immensely increased its potential as a commercial crop, which can be grown round-the-year.

BLOOM CLASSIFICATION

The number of cultivars of chrysanthemum grown in the world is incredibly large with more than 15,000 reported from Japan alone. The national chrysanthemum societies in each country classify the cultivars grown on the basis of bloom characteristics: (i) the relative number of two kinds of florets; (ii) the physical shape of florets, and (iii) the direction of growth and arrangement of florets.

The two kinds of florets that compose chrysanthemum bloom are:

Disc-floret situated in centre, tubular with five united petals. They are usually shorter and contain both male and female reproductive parts; they are called flowers.

Ray-floret which surround the disc-florets and are comparatively longer, vary in shape, colour and direction of growth. The ray-florets are called imperfect flower as they contain only the female reproductive parts.

While blooms of most varieties contain both types of florets some cultivars may have only one kind of floret. However, most of the cultivated forms in our country can be classified, either as large-flowered or small-flowered.

Large-flowered

Incurved. The ray-florets in this class are broad and curve upward and inward towards centre to give the bloom a globular shape. Disc is not visible.

Incurving. The ray-florets curve inward and upward in loose manner to give the bloom an open and airy appearance.

Reflexed. The ray-florets curve outward and downward away from centre so that their upper surface is seen. It is important to know that in early stages the inner florets in this class remain incurved. Disc is not visible.

Intermediate. The distinguishing feature of this class is that while outer ray-florets curve outward and downward showing upper surface the inner ones continue to remain incurved.

Irregular. This class has the characters of Intermediate class except that the ray-florets are twisted and turn irregularly.

Ball or rayonante. The ray-florets which are usually chanelled and closely packed radiate in all directions, thus giving the bloom the shape of a ball.

Quilled. The ray-florets are tubular like a quill with tips which may be open or closed.

Spider. The ray-florets are tubular and elongated but slightly curved with coiled or hooked tips.

Spoon. The ray-florets are tubular up to some length from the base and then open like a spatula.

Anemone. The disc is raised as a result of well-developed disc florets. The ray-florets may be ligulate or tubular.

Single. Straplike ray-florets in not more than 5 whorls. The disc is conspicuously visible but not raised as in the Anemone class.

Semidouble. Straplike ray-florets in more than 5 whorls with conspicuous disc as in single.

Small-flowered

Anemone. Same as in large-flowered except size of bloom.

Button. Blooms very small (2–3 cm) and compact like ball.

Korean (Single). Straplike ray-florets 5 or less in number of whorls. Disc conspicuously visible.

Korean (Double). Like the Korean class except that the number of whorls of ray-florets is more than five.

Decorative. Like Double Korean except that the disc is not visible due to presence of ray-florets all over the capitulum.

Pompon. Ray-florets short, broad and regularly arranged to give the bloom a compact, hemispherical shape. Disc not visible.

Stellate. Like Single Korean except that the ray-florets have often compressed sides and they are twisted.

Cineraria. Like Korean except the size of bloom which is not more than 3 cm in diameter.

Quilled. The ray-florets are tubular like a quill. The tips may be open or closed.

Semi-quill. The ray-florets are tubular up to some length and then open.

The above classification is used on exhibitions or shows where competitors put up their entries in different classes as specified in schedules so that comparison between dissimilar ones is avoided. There are however other criteria also for classifying chrysanthemum varieties: (i) suitability for different purposes like garland-making, cut-flower or pot culture; (ii) response to photoperiod and temperature for year-round blooming; (iii) natural blooming

season; and (iv) bloom colour. Various nursery catalogues list the varieties in groups based on these different criteria. Names of some of the selected varieties grown in India have been given below grouping them according to their utility and bloom colour.

Large-flowered (as exhibits)

White	*Yellow*	*Mauve Group*	*Red Group*
'Beauty'	'Chandrama'	'Grape Bowl'	'Bravo'
'Beatrice May'	'Sonar Bangla'	'Ajina Purple'	'Diamond Jubilee'
'Nob Hill'	'Shin Mei Getsu'	'Shirley Perfection'	'Distinction'
'Snow Ball'	'Super Giant'	'Mahatma Gandhi'	'Alfred Simpson'
'Willium Turner'	'Mountaineer'	'Dream Castle'	'Rustic'
'Kasturba Gandhi'	'J.S. Lloyed'	'Pink Turner'	'S.L. Andre Reffaud'
'General Petain'	'Mark Woolman'	'Peacock'	'Alfred Wilson'
'May Shoesmith'	'Triumphant'	'Classic Beauty'	'Mrs Helmepot'
'Jet Snow'	'Evening Star'	'Pink Giant'	'Gloria Deo'
'Innocence'	'Kikubiori'	'Raja'	'Mrs W.A. Reid'

Small-flowered (for pot culture)

White	*Yellow*	*Mauve Group*	*Red Group*
'Lohengrin'	'Topaz'	'Ace'	'Gem'
'Mercury'	'Indira'	'Sharad Prabha'	'Rakhee'
'Perfecta'	'Liliput'	'Modella'	'Red Gold'
'Jyotsna'	'Archana'	'Megami'	'Winifred'
'Honey Comb'	'Rani'	'Mohini'	'Flirt'
'Rita'	'Aparajita'	'Hemant Singar'	'Jaya'
'Niharika'	'Mayur'	'Appur'	'Jean'
'Sharad Shoba'	'Peet Singar'	'Charm'	'Garnet'
'Shweta Singar'	'Sharad Kanti'	'Alison'	'Arun Singar'
'Excelsior'	'Sonali Tara'	'Fantacy'	'Suhag Singar'

Small-flowered (for cut-flowers)

White	*Yellow*	*Mauve Group*	*Red Group*
'Birbal Sahni'	'Nanako'	'Sharad Prabha'	'Jubilee'
'Apsara'	'Jayanti'	'Ajay'	'Jaya'
'Himani'	'Sujata'	'Nilima'	'Danity Maid'
'Jyotsna'	'Kundan'	'Gaity'	'Blaze'
'Baggi'	'Freedom'	'Alison'	'Flirt'

Small-flowered (for religious offering and garland-making)

'Tushar'	'Meghdoot'
'Sharad Shoba'	'Sharada'
'Baggi'	'Archana'
'Santi'	'Vasantika'
'Himani'	'Basanti'
'Safed Revdi'	'Sonali Tara'
'Raja'	'Kasturi'
'Jawra'	'CS-16'
'Lilith'	'Prof. Harris'
'Jyotsna'	'Kundan'

CULTIVATION

Chrysanthemum plants respond differently to their environments, underground or aerial.

Underground Environment

Chrysanthemum plants have a fibrous root system which is sensitive to waterlogging, prone to attack by diseases and pests, but, fairly tolerent to drought. The media for growing should therefore be such which while retaining sufficient water for use by the plant should also allow proper aeration for respiring fine roots so that they do not die of choking or rotting. Sandy loams are ideal from this point. Apart from physical characteristics the chemical status of the medium is also important. Ideally, a pH of 6.2-6.7 is required. The optimal level of some of the essential elements in the medium should be:

Element	*Concentration (ppm)*
Nitrogen	10-50
Phosphorus	5-10
Potassium	30-50
Calcium	100-150
Boron	20
Copper	5
Manganese	3-4
Zinc	6-8

Aerial Environment

The response of chrysanthemum to its aerial environment has been

thoroughly studied by the scientists and the information emanating from these studies has been fully utilized by commercial growers in making revolutionary changes in growing techniques all over the world. The chief elements of aerial environment are light, temperature and humidity. Long days, higher light intensities and high temperatures encourage vegetative growth in chrysanthemum. Apart from quantitative effect the qualitative effect of these factors is very striking.

Light. It has been shown that chrysanthemum plants continue to grow vegetatively till the nights are shorter than critical level ($9\frac{1}{2}$ hr in most traditional varieties). The flower bud is initiated as the night length crosses this critical level. Discovery of this phenomenon termed 'photoperiodism' by Garner and Allard (1920) leads to the development of the technique of year-round and programmed-blooming by manipulating day and night-lengths using artificial light and shading material. The photoperiodism phenomenon has been shown to be the function of phytochrome pigments which has two forms, P_r which is red-absorbing and responsible for flower bud initiation and P_f which is far-red absorbing and inhibits flowering. With the onset of darkness the P_f form slowly converts into P_r form and the flower buds are initiated. Interruption of dark period with light reverses this conversion process and thus inhibits flowering. It has also been found that cultivars vary in their requirement of photo-induction period for flowering. This period is measured in weeks and cultivars have been classified into 6 to 15 weeks response group depending upon the number of weeks of short-days required by them respectively for flowering. This information helps the growers in planning the programme of blooming by photoperiodic control.

Temperature. Temperature is an equally important component of aerial environment affecting growth of the chrysanthemum plants. According to Cockshull (1976) the growth rate in chrysanthemum remains at low level at or below 10°C. As the temperature is raised to 15°C the growth rate increases rapidly. At higher temperatures (25°C), however long and thin stems are formed. A constant temperature of 16°C has been found to be the best for rooting of cuttings. On the basis of their response to temperature regarding flowering the cultivars have been grouped into three classes by Cathey:

Thermozero : Flowering at any temperature between 10° and 27°C but most consistently at 17°C night temperature.

Thermopositive : Continuous low temperature between 10° and 13°C inhibited or delayed bud initiation. At higher temperature 27°C bud initiation is rapid but flowering is delayed.

Thermonegative : Bud initiation occurs in low to high temperature between 10° and 27°C, but continuous high temperature delays bud development.

Interaction of light and temperature. The response of different cultivars

to photoperiod and temperature regimes has been studied and the cultivars classified into 6 ecotypes by Okada (1963).

Group	*Photoperiodic response*		*Temperature response*
	BUD INITIATION	DEVELOPMENT	
Autumn flowering	Short day	Short day	Flower bud initiation at 15°C or high temperature, development not inhibited at high temperature
Winter flowering	Short day	Short day	Flower bud initiation and development inhibited at high temperature
Summer flowering	Day neutral	Day neutral	Usually flower bud initiation takes place at 10°C
August flowering	Day neutral	Day neutral	Minimum temperature for initiation of flower bud at 15°C. Development inhibited at low temperature
September flowering	Day neutral	Short day	Same response as in August blooming
Okayama Heiwa-type flowering	Short day	Day neutral	Same as in Autumn flowering type

It is apparent therefore that temperature affects the bud initiation or development in all cultivars while the photoperiod may or may not.

Relative humidity. A relative humidity between 70 and 90% is optimum for growth of chrysanthemum. Higher levels encourage soft growth and fungal diseases. Dry weather at flowering is desirable. In India where chrysanthemum is almost exclusively grown outdoors the humidity cannot be controlled. It is advisable, therefore, that the crop may be grown commercially in drier tracts, or, at least cultivars should be chosen in such a way that at flowering there are no rains.

COMMON CULTURAL PRACTICES

Propagation, feeding, water management, growth regulation and protection are common cultural requirements to be looked into for growing chrysanthemum successfully for hobby, for commerce or exhibition. The essentials of these are elaborated.

Propagation. The age-old method of propagation from suckers is followed. The advantages of this method are natural availability of suckers, their easy establishment and almost no mortality and early take-off due to already persistent roots. The main disadvantages are transmission of parental diseases to progeny and lack of uniformity and poor flower quality.

The method based on scientific research ensures healthy, disease-free and uniform plant population bearing high-quality blooms. The method consists of raising disease-free stock plants which are kept in vigorous growing condition for taking terminal vegetative shoot cuttings. For rooting ideally, (i) sterilized medium for inserting cuttings, builders sand-heated over an iron pan and cooled (NBRI, Lucknow); (ii) 16°C night temperature; (iii) good light but avoiding direct sunlight during mid-day; (iv) use of chemical root -promoting auxin (quick dip in 2,000 ppm IBA); and (v) use of Thiram and Captan to control damping-off.

Terminal cuttings, 5–6 cm long, dipped in fungicide and rooting hormone are inserted 3 cm × 5 cm apart and watered immediately and thereafter regularly. They are ready for transplanting in 3–4 weeks. Specialised propagators in many countries resort to mass production of virus-free cuttings by tissue culture for commerce. This method has been standardized at the NBRI, Lucknow, in 'Birbal Sahni', 'Pandhari Revdi' and 'Otome Zakura' (Prasad and Chaturvedi, 1982, 1983).

Feeding. The growth of newly propagated sapling largely depends upon the nutrient supply made available to it. The emphasis in the early stages should be on nitrogen supply using organic manures. Phosphorus is best applied as basal dressing since it is released slowly. Proportion of potassium should be increased as the flower buds appear. The experiments conducted at different centres of the All-India Co-ordinated Floriculture Improvement Project of ICAR propose definite recommendations of field doses for major nutrients. Pune centre at Ganeshkhind recommends 200 kg each of N, P_2O_5 and K_2O per hectare for maximum benefit in 'Zipri'. The Ludhiana centre at Punjab Agricultural University recommends, with a basal dose of 5 kg farmyard manure, application of 40 g each of N and P_2O_5 and 20 g of K_2O per m^2. Kalyani centre at Bidhan Chandra Krishi Vishwavidyalaya, West Bengal, recommends 40 g each of N, P_2O_5 and K_2O per m^2 for maximum yield. Half the dose of N and full of P_2O_5 and K_2O was applied at the time of planting and the remaining half dose of N was given 40 days after the planting in these experiments. A different approach to feeding is the use of slow-release fertilizers—urea formaldehyde nitrogen, fritted potassium, magnesium ammonium phosphate and coated inorganic fertilizers. The advantage of slow-release fertilizers is that a single application is required which is not possible with readily soluble traditional fertilizers. Coated fertilizers in combination with liquid application of N and K have been reported to produce better crop (Simpson, 1975).

Water management. The frequency of irrigation depends on the stage of growth, soil and weather condition, besides on whether the plant is grown in the ground or in the pot. The soil is to be kept constantly moist till the plants get established from planting, after which the condition of scarcity and sufficiency of water should alternate for ideal growth. To avoid waterlogging during the rainy

season plants are usually planted on ridges. Potted plants are either provided temporary shelter or kept in horizontal position during a constant downpour. While irrigating the beds, a thorough drenching is preferable to surface wetting. In our country the method of irrigating the fields is by channel system and for pots manual bucket system. Both these systems are inefficient due to wastage of water. The overhead sprinkler system and various soaking systems followed in the developed countries though economize water, require considerable investment for installation.

PLANT PROTECTION

Pests

Aphids. These are small greenish-to-black dot-like insects which are seen in large number sucking the sap from tender parts like stem tips, flower buds and young leaves. Mild insecticides like tobacco leaf decoction or Malathion is effective against them.

Red spider mite. Very minute dot-like insects of red colour seen on the undersurface of leaves, particularly in hot dry season. Spraying with Metasystox or Kelthane controls the pest.

Hairy caterpillar (Diacrisia obliqua). Also called Bihar caterpillar, attacks the plants in the rainy season and continues till winter. Manual collection in mild attacks and spray of 0.2% Ekalux at weekly intervals have been found an effective control.

Grub (Holotrichia *sp.*). This pest cuts the underground part of stem and roots specially in hot weather. Soil application of Aldrin or Lindane are effective control measures.

Thrips. Thrips cause damage to summer blooming varieties and spraying Malathion or Lindane is effective against them.

Earthworms. The common earthworms pose problem during the rainy season specially in pot-grown plants. As soil drench 1–2 applications of lime water kills them.

Diseases

Root rot (*caused by* Pythium *spp. or* Rhizoctonia *sp.*). Also called collar rot or foot rot. It is the damping-off disease of the cuttings which turn soft at soil level and wilt. Use of sterilized medium, and treatment of cuttings and the medium with Thiram and Captan effectively control it.

Leaf spot (caused by Septoria chrysanthemella). Greyish brown spots appear on leaves which turn yellow and ultimately die. The disease spreads from below upwards. It can be controlled by Bavistin and Dithane.

Wilt (caused by Verticillium *spp.).* The leaves turn yellow to grey and the

branch or whole plant wilts gradually. The use of disease-free planting material and planting in sterilized medium prevent the infection.

Stunt (caused by stunt virus). Spreads by mechanical means through cutting knife or secateur resulting in the overall dwarfing, paleness in leaf colour and the appearance of small yellow green dots in summer in some varieties. Not using the same knife for diseased and healthy plants during pinching or cutting prevents its spread. Rouging diseased plants should be practised.

Aspermy (caused by aspermy virus). This virus is transmitted by aphids and results in distortion of flower and reduction in flower size with florets becoming wary. Heat therapy considerably reduces the incidence and consists of keeping the plant at 40°C for 2 hours.

GROWTH REGULATION

When allowed to grow naturally, most of the cultivars of chrysanthemum leave something to be desired either in plant form, height, branching, quantity, quality or the time of bloom. To obtain the results in the desired direction certain growth regulatory methods are adopted.

Physical Methods

Pinching. Removing the terminal growing portion along with a portion of stem is called pinching. Pinching reduces the height but promotes axillary branching, delays flowering and helps in breaking rosetting.

Disbudding. Removing unwanted flower buds is called disbudding. It is practised to reduce flower number, improve spray-form and to increase the flower size.

Dis-shooting. Removal of undesirable branches is known as dis-shooting. Its aim is to reduce the number of branches thereby the number of blooms, to improve the spray form and to increase the bloom size.

Staking. Giving physical support to the plant or branches is called staking. It prevents them from falling and leads them to grow in the desired direction.

Chemical Methods

Chemical root promotion. Indole butyric acid, growth retardant SADH or DAMN (Diaminomaleonitrile) have been found to promote the rooting in chrysanthemum. The proprietary rooting hormones available in the market are also combinations of talc with auxins.

Chemical growth retardation. B-Nine and Phosphon are the two commonly employed growth retardants for chrysanthemum which are used as spray and soil drench respectively. Other chemicals effective for this purpose are ACPA, Chloremquat, Ancymidol and Alden.

Growth-promoting chemical. Gibberellic acid causes elongation of stem, pedicel or florets depending on the stage of the plant when it is applied. This chemical is also effective in breaking the rosetting in combination with chilling treatment.

Chemical pinching. Certain chemical preparations like UBI P293, Emgard 2077 and Off-shoot 'O' have been reported to be effective pinching agents for chrysanthemum. These chemicals contain certain alkyl esters which are responsible for selective killing of the terminal buds.

Cultural Practices

Cultural factors such as planting time, medium and pot size, amount and frequency of watering, light and temperature can be manipulated to influence growth in chrysanthemum to achieve specific objectives.

Plant height. Constant water supply, early planting, semi-shaded location and bigger size of pot tend to increase the height of the plant.

Blooming time. Manipulation of day length and temperature at different stages of growth has been successfully used to obtain blooms in chrysanthemums on any desired date. This method has revolutionized the chrysanthemum trade in many developed countries and is also being used at 'Dochi' in Shimla Hills, from where potted plants in bloom are supplied to Bombay and Delhi markets the year round.

Bloom quality. It is also possible to increase the bloom size and improve the spray form by a technique called 'Interrupted lighting' which consists of alternating short and long days in definite numbers and sequence (12 SD–10 LD–SD till anthesis).

Genetic Method

The methods of growth regulation described above, though reliable, entail some additional expenditure by way of labour, skill, chemical or infrastructure. The cheapest way, therefore, is to breed varieties which naturally would possess the desired combination of characters. A recent example of this method is the evolution of scores of new varieties at the NBRI, Lucknow, which naturally possess the desired characters rendering other methods of growth regulation unnecessary. The reason, the newly developed dwarf and compact-growing varieties like 'Arun Singar', 'Sharad Singar', 'Hemant Singar' and 'Suhag Singar' have enabled the grower to do away with the cumbersome and labour-intensive practices of pinching and staking. Similarly the evolution of out-of-season blooming varieties such as 'Jyoti' and 'Jwala' for summer, 'Varsha' and 'Rim Jhim' for the rainy season, 'Sharada' and 'Sharad Mala' for early autumn and 'Jaya' and 'Vasantika' for late winter have rendered the photoperiod and temperature control unnecessary for getting blooms in these seasons. This saves a lot of expenditure.

ART OF CHRYSANTHEMUM GROWING

Training chrysanthemum plants in different attractive styles is an art in which the Japanese growers have attained perfection. Standard and bush are the two styles in which the Indian growers have been training the chrysanthemum plants from the British period. Recently, at the NBRI, Lucknow, a few other highly attractive styles like cascade, sen-rin tsukuri, hanging baskets and various deviations of mini-culture have been successfully tried and popularized. The essential cultural modifications applied for training in these different styles have been summarized.

Large-flowered

Standard form. This style consists of training the plant into 1–3 erect stems, each bearing single, giant, terminal bloom. The plants are raised from cuttings made in July-August. If single flower is desired no pinching is done. On the contrary, for more flowers the rooted cutting is pinched once after about a month

Fig. 1. A group of large-flowered plants trained as 'standards'.

of planting. The resultant branches are subjected to dis-shooting leaving only as many branches as the number of blooms desired, and stakes of split bamboo tied to each of them. As the flower buds appear, disbudding is practised to leave only a single bud per shoot. Consequently, a standard, bearing extra-large bloom or blooms, which are usually grown for garden display and competing, are obtained (Fig. 1).

Sen-rin tsukuri. This is a Japanese word meaning 'making thousand blooms'. Some profuse-branching, large-flowered cultivars are more suitable for this type of culture (Fig. 2). The plants are started from early planted suckers which are encouraged to grow vigorously by frequent feeding and pinching so that a profusely-branched plant is ready. A split-bamboo frame, resembling an umbrella with several rings arranged concentrically in horizontal plane is constructed around this plant. The branches of the plant are then carefully tied to the bamboo rings at an equal distance. Disbudding is practised to obtain only a single bloom on each terminal shoot. At the NBRI show, plants trained in this style and bearing about 100 large-flowered blooms never fail to attract the onlooker and win their admiration.

Small-flowered

Bush form. An ideal bush of chrysanthemum grown in 25 cm pot is about 60 cm high from the rim of container with a floral head of equal diameter, with blooms evenly spread and flowering all at a time. Plants for this purpose are raised

Fig. 2. A large-flowered plant trained as 'Sen-rin tsukuri'

from suckers taken from profuse-branching cultivars soon after the winter season and are encouraged to grow vigorously. Pinching is practised frequently to keep the plant dwarf and for it to develop into a round-headed bush. Stakes are used all around the plant to prevent branches from falling.

Cascade form. In this style the plants are trained in elongated shape and gradually bent downwards in such a way that the plant tip points towards the ground. The whole plant is somewhat compressed with blooms in one plane giving an appearance of a water-fall. Cultivars with elongated internodes, pliable stem and short pedicel but profuse-branching habit are more suitable for this style of training. The essential features of culture are selective pinching, gradual bending and frequent tying of branches to a split-bamboo frame to keep the plant in one compressed plane. When in bloom, the container and the frame is hidden below the leaves and flowers making the specimen highly attractive.

Hanging basket. Hanging baskets of chrysanthemums can be easily prepared by planting 30 to 40 rooted cuttings of dwarf, small-flowered cultivars late in the season in a single basket filled with compost. These are ideal for veranda and terraces.

Mini-culture. The newly developed dwarf cultivars at the NBRI, Lucknow, have been found ideal for growing in mini containers 10 cm or less in diameter (even in ice-cream cups). These plants are raised from the late-struck cuttings which are not allowed to grow more than 15 cm high. Such profusely branched plants may bear 50–60 blooms or less. When in bloom these mini plants can be used for interior decoration as such or can also be transplanted in flower vases in a group of 3 or 4 to make artistic arrangements like cut-flower arrangement, or in flat trays to make attractive landscapes in conjunction with other items such as mini-huts, streams, ponds and hillocks (Fig. 3).

GROWING FOR COMMERCE

In India the commercial cultivation of chrysanthemum is for loose flowers for worship and garland-making. To a very small extent chrysanthemum is also grown for sale as cut-flower with long stem and as potted plants. Some nurserymen also trade planting-material of different varieties on a small scale.

Field culture. The main centres of field cultivation of chrysanthemums in India are Madurai, Chingleput and Coimbatore in Tamil Nadu; Malur, Hosur, Chikballapur and Devenhalli in Karnataka; Ahmednagar and Pune in Maharashtra; Indore, Ratlam and Ujjain in Madhya Pradesh; Pushkar in Rajasthan; and Madhupur and Deogarh in Bihar. Yellow and white-flowered varieties bearing 4–6 cm blooms are preferred for this purpose. The field is prepared by ploughing twice or thrice, followed by application of 37–49 tonnes of farmyard manure per hectare. Suckers are planted on ridges. A distance of

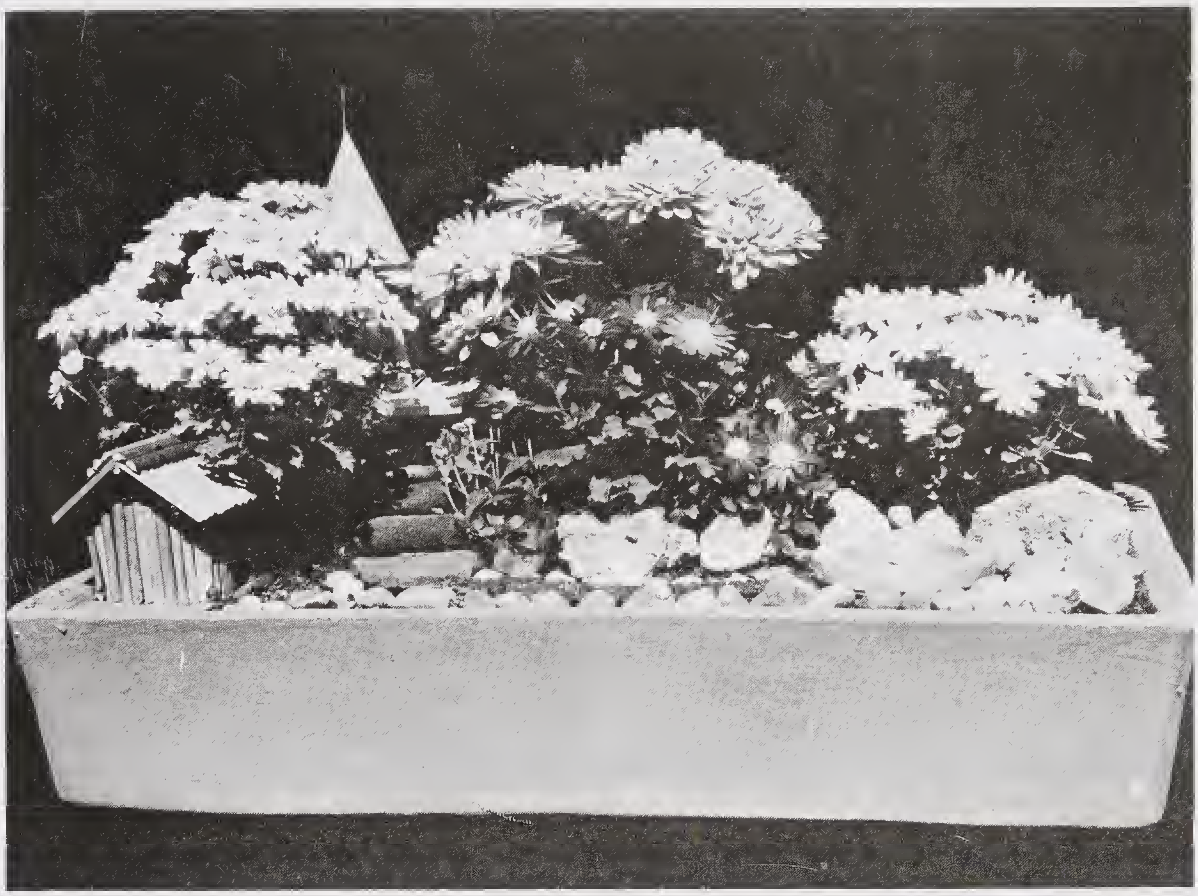

Fig. 3. Landscape culture in a tray of 30 cm × 45 cm size.

30 cm × 30 cm for planting has been recommended by Pune centre of the All-India Co-ordinated Floriculture Improvement Project for 'Zipri'. Planting time depends on the region and ranges from March to August. Wells are the main source of irrigation in most places and flooding the beds by channel system is the usual mode. Interculture mainly consists of 8–10 weedings which may or may not be accompanied by hoeing. Hardly any protection measures are used against pests and diseases resulting in considerable losses in bad years. Flowers are harvested by hand-picking every 3–4 days with or without pedicel (for giant-size garlands with pedicel). Flowering season varies from region to region. The natural blooming season, for all regions combined, lasts from July to February with traditional cultivars and techniques. The yield ranges from 3–6 tonnes of loose flowers. Flowers are packed in bamboo baskets or gunny bags for marketing. The capacity of bamboo basket ranges from 1 to 7 kg while the gunny bag accommodate 30 kg of loose flowers. In the wholesale markets the flowers are stored at room temperature heaped on *pukka* floors. The average storage life is said to be 4 days under these conditions. After deduction of the cost of cultivation

and overhead charges the net profit for the grower ranges from Rs 5,000 to Rs 15,000 depending on the season, region and the marketing conditions.

Cut-flower production. The cut-flower production method differs from loose flower cultivation in a variety of ways. Instead of starting early from suckers of white- and yellow-flowered cultivars rooted cuttings of a wide range of different coloured varieties of both large- and small-flowered types are planted late in the season at a much closer distance (20 cm × 20 cm). One pinch is given to the plants of medium- and long-duration cultivars. In 1 hectare 175,000 cuttings can be planted even after leaving 30% for paths and irrigation channels. Each of these can give 1 or 2 sprays depending on whether pinching is done or not. Obviously more than 100,000 sprays can be obtained if the cultivation is restricted to traditional varieties grown for natural season production only. Even then the profits could be much higher than in loose-flower production. The limitation, however, is, that sprays with long stem are in demand only in big cities in our country. Whereas the loose flowers have a wider acceptance even in smaller towns.

Pot-plant production. 'Pot-mum' is the term given to this rather modern method in which cuttings are planted in handy, small-size pots. The number of cuttings depend on pot size. One, 3, 5 or 7 cuttings are planted in pots of 9, 10.8, 14 and 15.2 cm size respectively. Pots measuring 14 cm across are most common. Uniform cuttings are used for planting in each pot. They are spaced evenly while planting them along the periphery in each pot at uniform depth. Frequent liquid feeding in late planting keeps the plants vigorously growing, one pinch and use of chemical growth retardant such as Phosphon or B-Nine keeps them dwarf. It has been calculated that as many as 175,000 pots measuring 14 cm across can be planted in one season in natural season production in every hectare. Each such pot can fetch Rs 5–10 in metropolitan markets. This type of culture is however highly intensive and requires precise knowledge of varietal behaviour and needs intensive care. The profits too are much higher.

PROBLEMS AND POTENTIALITIES

Chrysanthemums can be grown to perfection by traditional methods provided weather is favourable and no outbreak of disease occurs. On the contrary, even the best growers are not confident of assured results as unfavourable weather and diseases take a heavy toll, both in terms of quantity and quality. This uncertainty, combined with short-blooming season, post-harvest spoilage and glut conditions dampen the spirit of any prospective grower whether he be a novice, professional or a commercial one. Similar situation prevailed even in advanced countries like the UK and the USA few decades ago. However, the situation has changed entirely in those countries where application of scientific research have converted this crop into a dependable one more than

any other ornamental crop.

Eliminating Crop Failure

Use of disease-free planting material, sterilization of planting medium, precise water management, judicious feeding and protection from diseases and pests eliminates the possibilities of crop failure.

Assured and Increased Profits

Profits depend on the yield, quality and timing of flowering. Right choice of variety and providing ideal conditions for growth of plants ensures high yield and superior quality. Yield can be doubled or trebled by growing 2 or 3 crops in the same area within a year either by using newly developed ecotypes which naturally bloom in different seasons or by resorting to controlled blooming as is done in glass-house culture. Right timing of the crops goes a long way in increased profits to the grower. The rates of loose flowers in Indian markets fluctuate from Rs 2 to 20/kg depending on the demand-and-supply condition. Herein lies a great scope for several-fold increase in profits. Researches by plant physiologists and breeders have enabled growers to obtain chrysanthemum blooms on the date of their own choosing. Obviously one can get much more profit by producing flowers at a time when they fetch higher price in the market. This can be done in two ways:

By growing in controlled environment. This method although foolproof, requires considerable expenditure by way of erecting closed structure and controlling light and temperature inside. The crop produced this way must necessarily be sold at a much higher price than the one produced outdoors. Only the effluent can afford such a crop. This method is therefore recommended mainly for 'pot-mum' production and for very high-quality cut-flowers for sale in 5-star hotels and at the florists' shops in metropolitan cities like Delhi, Calcutta or Bombay.

By planting newly developed ecotypes. Several new cultivars have been evolved at the NBRI, Lucknow, which naturally bloom in different seasons when planted according to a given schedule as detailed.

Cultivar	*Date of planting*	*Blooming season*
'Jwala', 'Jyoti'	January	Summer
'Varsha', 'Meghdoot'	February	Rainy Season
'Sharada', 'Sharad Shobha'	March	Sep.-Oct.
'Sharad Mala', 'Megami' and 'Sharad Kanti'	July	Oct.-Nov.
All traditional cvs	July	Nov.-Dec.
'Vasantika', 'Jaya'	August	Dec.-Jan.
'Illini Cascade'	August	Feb.-Mar.

As the growing of these cultivars does not require any extra expenditure,

their cost of production would be same as of traditional cultivars. On the other hand, as the flowers would be produced when there is scarcity in the market, the grower would get a higher price than when he grows conventional cultivars. Besides the price would be within the reach of common man. Thus these varieties are worth recommending for open-field cultivation of loose flower. Moreover some of the early varieties can easily fit in crop rotation as the field would be free for the *rabi* crop.

Post-harvest Spoilage

Although chrysanthemums have a fairly long post-harvest life, the losses due to faulty picking, rough handling during transit and shabby storage at room conditions in the wholesale market can be minimised. In the advanced countries, the whole crop is harvested at a time, followed by opening the buds using chemical holding solutions (Figs. 4A, 4B). The cut-flowers can then be stored at approximately 0°C for 4 weeks. The technique called hypobaric storage enables even storing of potted plants in bloom for 4 weeks.

While we can certainly benefit from these findings, there is a need for some fundamental research for enhancement of post-harvest life of loose flowers which form the bulk of our country's total production. Prof. Mohan Ram and his group

Fig. 4A. Incomplete opening of flower buds of cut spray kept in plain water.

Fig 4B. Complete opening of flower buds of cut spray kept in chemical solution.

are doing pioneering work in this field at the Delhi University. Other research institutes, agricultural universities and centres under All-India Co-ordinated Floriculture Improvement Project are also playing a useful role in generating and transmitting information for the benefit of the growers.

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6

Dahlia

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DAHLIA, in India, is like an uncut diamond. The diamond is not at its sparkling splendour because no one bothered to take the right care of it. In fact it can well vie for the top place among all the popular flowers in India.

If earning dollars be the chief criterion for a successful commercial exploitation, dahlia may top the list provided it is properly cared for. Holland sells 50 million dahlia tubers annually in the international market. With indigenous expertise, India can produce an equal quantity of tubers having the same international quality at a much lower cost. Tuber materials (field tubers and pot tubers are usually accepted in the international market) may be produced as a by-product of the normal dahlia-growing in Indian plains, through late-cutting, a method developed in this country. This method is capable of proliferating dahlia tubers in such a great quantity in our climates that probably no other country can multiply dahlias so fast. Hand-pollinated dahlia seeds from quality cultivars find a good demand in the international market and such seeds may be produced here more easily. Indian climates are so congenial to breeding dahlia that cultivars evolved here may be a first-rate commodity in the international market. Dahlias are not adversely affected by climatic fluctuations, a great advantage not found in any other popular flower.

Dahlia flowers in full glory for over 4 months at a stretch in many parts of the vast plains and at different times in the different climates of the hills. It flowers in summer in the hills and in winter in the plains. India is probably the only country which can boast of producing fresh dahlia flowers naturally the year round. The vase life of the 'Pompon' is very long and it is also not difficult to transport this type even to a distant destination. Dahlia field tubers, pot tubers, tuber divisions, open-pollinated seeds, hand-pollinated seeds and cut-flowers are all good commercial items. It indeed is good for exhibition or garden-display, as

also for commerce.

Use of Dahlias

Dahlia, a versatile flower, is extensively used for exhibition, garden-display, and home decoration. All types of dahlias are favourities as exhibits, but the cynosure is the 'Giant' whose flowers measure over 25.4 cm across. The flowerpot 'Giant' dahlia is a speciality of the Indian exhibitions. These are also popular for garden, terrace (roof), garden or verandah display. In parks and gardens, a bed of dahlias in flower will compel attention even from a distance. For garden-display all types are extensively used. There is a dwarf-growing type, which is called 'border dahlia' in common parlance, and this is highly suitable for borders or beds since they do not require any staking. In India, 'Giant' or 'Large' dahlias are much in use for altar decoration. There are certain types of dahlias that look even better indoors than other plants. The long-stemmed dahlia flowers of various forms, colours, and sizes are indeed flower arrangers' delight. The most prominent among the types used for flower arrangement are 'Pompon', 'Small Semi-Cactus', 'Small Cactus', and 'Water Lily'. However, 'Pompons' also make moderately good garlands.

INDIA'S CONTRIBUTIONS TO THE WORLD DAHLIAS

In India, dahlia was first introduced in 1857 under the auspices of the (Royal) Agri-Horticultural Society of India, Calcutta. The flowerpot dahlia forms a major contribution of this country to the world of dahlia and these must have been cultivated even before 1935. The other notable contributions are the late-cutting method of dahlia preservation developed in 1960; planned self-pollinating breeding in 1981, and planned breeding with only first-year seedlings in 1982—the importance of the last two experiments being that they give a new theory, which may be called 'Mutation Theory of Dahlia Evolution', a firm footing. All the above-mentioned 4 points have been discussed in the text. From the dahlia-literature point of view, books so far produced in India are, one in Bengali (Bhikshu Buddhadev and Sengupta, 1978) and the other in English (Swami Vinayananda, 1985). The English book is meant for the whole of the Indian subcontinent. There is probably no other book that discusses dahlia cultivation in tropical climates.

Flowerpot dahlias. Flowerpot dahlias (Swami Vinayananda, 1984) are most popular for growing 'Giant' dahlias which produce enormously large blooms. In order to produce the largest possible flower for the plant, only the crown bud (first bud) is allowed to develop into a flower while

all other buds and new shoots are rubbed off as soon as possible. The reason a flowerpot 'Giant' cultivar produces only one flower. From transplanting, dahlia takes 60 to 80 days to produce the flower on the crown bud. A liquid feed helps to produce larger and better flowers and an organic liquid manure is considered better than an inorganic liquid feed. Commonly, 26 cm pots are used for flowerpot dahlias and a pot of this size contains just 6 litres (when measured with a litre-graduated bucket) of potting compost.

One popular potting compost: 3 parts of loamy soil, 3 parts of cowdung manure, and 2 parts of leaf-mould are first mixed thoroughly; to every 6 litres of this mixture, 30 g bone-meal, 20 g hoof-and-horn meal, 15 g single superphosphate, and 5 g sulphate of potash are further added. Potting compost should be prepared a month or so before use.

Green plants or tuber divisions nurtured in small pots are transplanted in flowerpots (and also in ground) with their root balls intact. The booster-feed in flowerpots is given around 15 days from transplanting; 50 g powdered mustard or some other oilcake is also given to every plant. At bud-initiation, a plant gets the bud-feed. The supplemental granular bud-feed consists of 30 g sterameal (7 : 10 : 5) and 5 g magnesium sulphate. All granular feed should be given by the ring method and there should be copious watering for three consecutive days following an application of granular feeds. Liquid manuring starts about a month from the transplantation of green plants, and it is usually applied twice a week.

Late-cuttings. The late-cutting method (Swami Vinayananda, 1984) of dahlia preservation has satisfactorily solved a very long-standing problem. This method has also started spreading to the advanced dahlia-growing countries. Tender basal shoots from the plants in flower are taken as cuttings and the resultant plants (stock plants) are kept in growing condition. The stock plants are made bushy by continual pinching of the growing ends—pinching is an essential feature of this method in order to get quality cuttings. Some 5 rooted-late-cuttings are planted in a 26 cm flowerpot and the same potting compost may be used. But there should be no further feeding. During very hot summer days, the stock plants should be kept in such a place where they get only the morning sun for 2 hr. Cuttings to make green plants may be taken from mid-August through November, or, further where the dahlia season is considerably long, from the stock plants. The late-cutting is particularly suitable for the plains.

Mutation Theory of Dahlia Evolution. The dahlia was introduced into England in 1803, but from a few varieties it soon had more than 300 varieties within the first 15 years. 'The earliest dahlia blooms grown in the British Isles were purple or crimson, but within 15 years the wide range of colours we know today and many variations in form had occurred' (National Dahlia Society, England, 1981). It

should be remembered that this was the period when planned breeding was unknown in dahlias. This was also the time when almost nothing was understood about the mutants and particularly the apical mutants and the question of stabilizing them did not arise at all.

The academic botanists are at one with one another that *Dahlia coccinea* contributed most to the evolution of the present day dahlias. *Dahlia coccinea* was one original species that was sent to Cavanilles from Mexico and this is also the most wide-ranging species in the habitat of the dahlias. About this species it has been noted that: (i) 'It is my belief that *D. coccinea* is a single, very wide ranging, polymorphic species and that its 'varieties' are often merely extreme variants, and (ii) 'in one instance both diploids and tetraploids were found in the same population' (Sorensen, 1969). The innate tendency to vary is probably most noticed in the case of *Dahlia coccinea* but many other dahlia species also have this propensity in varying degrees.

Two experiments (Swami Vinayananda, 1985) that have been carried out in India are of particular importance in connection with the Mutation Theory. The first is a planned self-pollinating breeding. From one such breeding a cultivar 'Swami Madhavananda' was originated. It can now be safely asserted that more than 25% cultivars are actually self-compatible. This is, however, diametrically opposite to the very long-standing theory, which was advocated by the academic botanists. According to them, all dahlia cultivars (hybrids) are self-incompatible. All the breeding theories developed in the West are dependent on this theory. There was, however, a very clear proof (Sorensen, 1969) that hybrids raised from *Dahlia scapigera* × *Dahlia coccinea* were self-compatible (the present author came to know about this paper only in November 1984). It is not difficult to find out whether a cultivar is self-compatible or not but the work involved is indeed laborious. The second experiment was a planned breeding with only promising first-year seedlings. It has been found that these seedlings are capable of producing equally good seeds (in all respects) in comparison with the seeds from recognized cultivars. From the first such breeding a cultivar 'Lord Buddha' was originated.

The dahlia mutates of and on. The apical portion of the plant mutates mostly but sometimes the whole plant or the tuber also mutates. When the tuber itself mutated the same was more easily preserved and this happened from the very early days of dahlia cultivation. Many of the mutants have altogether new forms or sizes. A mutant of the massive Giant 'Kelvin Rose' was spotted in Calcutta area in the early eighties. Almost all the petals of this new mutant have 'spoon' formation according to the chrysanthemum terminology — the petal is tubular with the end opening like a spoon (Fig. 1). When an enterprising breeder now gets a mutant having some new form he consciously tries to breed with it in the hope of originating a new type of dahlia. If the mutant is viable as a seed-

Fig. 1. 'Kelvin Rose' Mutant: Petals have the spoon formation.

parent or pollen-parent, it then does comply. In the early days of dahlia cultivation the apical mutants must have produced seeds as seed-parent, pollen-parent or self seeds, though these mutants probably did not survive for more than one season. Self-pollinated seeds seem to pass the new traits more easily. Both tuber mutants and apical mutants did their duty to pass the new traits through their offspring though the apical mutants could not be stabilized in the early days of dahlia cultivation. It seems to be most probable that dahlia has got so many forms and sizes mostly through the mutants. And because many dahlia species have a natural tendency to vary, so many variations in the dahlia have come so early and so easily. Mutation theory of dahlia evolution may stand even without self-pollinated seeds and seeds from the first-year seedlings, but these two do give it a very firm footing.

BRIDGING HILL AREAS AND PLAINS

Most of our hill areas have temperate climates while the vast plains mostly have tropical climates. Dahlia cultivation in hill areas is practically identical with that of the West. In the West, the tubers are started in greenhouse (glass-house), but here they are started when the climate becomes sufficiently warm. Any good dahlia book (e.g. Hammett, 1980) written for the temperate climate should be a useful guide for growing dahlias in our hill areas. August and September are the best months for the Dahlia species to flower in Mexico and other habitats, the flowering period in most of the hill areas in India tallies with this. But in many places of the hill areas, the dahlia also flower much earlier. The story of dahlia cultivation in Indian plains is altogether different, however, the usual flowering period starts from November and it continues till the end of February or even later. While dahlia books meant for temperate climates are useful for hill areas, they are hardly of any use for growing dahlias in the plains. Cultivation, flowering period and many other aspects are altogether different in these two climatically different areas. Dahlia season starts in one place when it ends in the other—dahlias are growing like this in India in her hill areas and plains!

The seemingly unbridgeable dahlia cultivation in hill areas and plains may not be really that unbridgeable any longer, and for the sake of better growing it has now become essential to bridge them. Dahlia tubers and seeds do not care for a period of dormancy if there be congenial conditions for growing. If dahlia tubers are sent immediately on lifting from hill areas to plains or *vice versa*, they start growing satisfactorily in the new congenial condition.

From the transport point of view, pot tubers and tuber divisions are better than the field tubers. In America and Australia, tubers are divided immediately on lifting them from the ground and, according to some dahlia specialists there, the new eyes are visible at this time. This was tried by this author and it was found that the eyes were not really visible in Delhi climate. But, at the same time, it was found that the lifted field tubers could be successfully divided with a piece of the crown (Fig. 2). This is done just like tuber divisions of sprouted field tubers—the sprouts are imaginary here and this is the only difference.

Transport of freshly lifted tuber materials from plains to hill areas and *vice versa* is going to open up new vistas for the dahlia breeders of this country. The same new promising seedlings may be tested and flowered twice a year and that too in altogether different climates. This will help the forthcoming Indian cultivars to be better tested and to be finally evaluated by the end of the second year. With the recent transport improvements, sending or getting dahlia tuber materials should not be much of a problem.

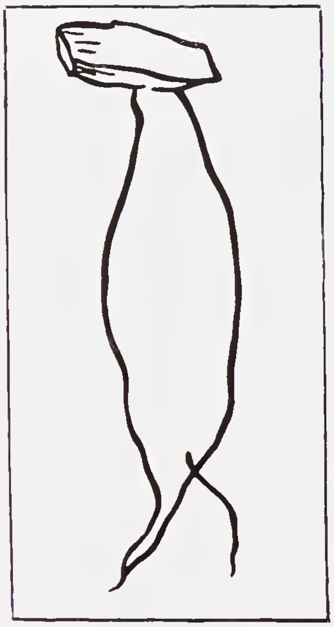

Fig. 2. Tuber division on lifting. It is complete with a piece of the crown.

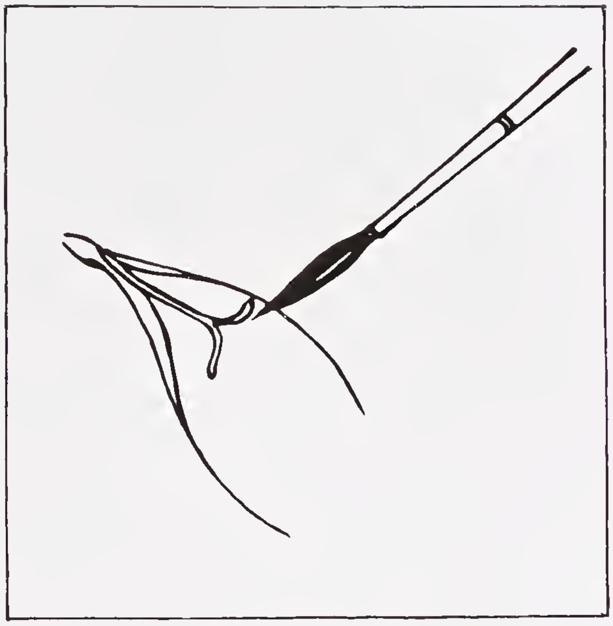

Fig. 3. Actual operation of hand-pollination.

DAHLIA CULTIVATION

Growing in Ground

Dahlias love sun above and moist soil below. A dahlia bed should have only two rows of plants though the bed can be of any length. A bed is first worked to a depth of 30 cm. A 10 to 15 cm thick layer of cowdung manure is first spread on the bed and then mixed thoroughly to the whole depth. For transplanted green plants or tuber materials the different times of application of supplemental feeds are just like flowerpot dahlias; the ring round the main stem for applying supplemental granular feeds should have a minimum radius of 15 cm. For booster-feed, 5–8 g of some NPK fertilizer (like 14:28:14 or 14:36:12) has to be given and for bud-feed 7–10 g of an NPK fertilizer and 5 g of magnesium sulphate have to be given to every plant of garden-display. Garden-display dahlia plants are stopped when they are around 20 cm tall and allowed to have many laterals. These laterals are to flower only at the central bud. These laterals produce many laterals again. One or two only, arising from every old lateral, are allowed to grow and produce flowers on their central buds. All the other new laterals are disbranched at the earliest, and companion buds are always disbudded.

For exhibition quality flowers on ground, dahlias are best cultivated by compost-in-pits method. A pit 40 cm deep and 40 cm in diameter is made

and filled with the potting compost meant for flowerpot dahlias. Supplemental granular and liquid feeds are given like flowerpot dahlias (discussed under 'India's contributions to the world of dahlias'). Disbudding and disbranching are also done thoroughly. Flowers of the first flush usually have better depth and this should be remembered while producing exhibition flowers.

Growing Flowers for Market

Growing for cut-flowers is practically the same as the growing in ground but the selection of the right cultivars is a condition necessary for success. Beds are prepared like the garden-display dahlias. The question of cutting down the expenditure is naturally very important in this type of cultivation. With this in view, only booster-feed is given as supplemental feed to these plants. The booster-feed is made of 4–7 g of urea for every plant. If found necessary, they should be given the same bud-feed meant for the garden-display dahlias. Producing cut-flowers demands a maximum number of flowers in a steady succession from a plant. A suitable cultivar should branch freely but it should also be encouraged to do so by stopping like garden-display plants. And in order to get a maximum number of flowers, a minimum disbranching is practised. Thus, all laterals including the new laterals arising from the older ones are allowed to flower. But companion buds are disbudded without fail.

Dahlias in Exhibitions

In India dahlias are exhibited both as cut flowers and flowerpot dahlias. Flowerpot dahlias, particularly the 'Giants', are most impressive and they are also most popular. The quality of flowers in this country is on par with that of the advanced dahlia-growing countries. India has no scheme of dahlia classification for exhibition of her own as yet, but the dahlia exhibitions are very much influenced by the British classification from the very beginning. And the same with some minor modifications should suit India admirably.

In the late sixties, there was a move to form an international scheme of dahlia classification for exhibition. England was given the responsibility of formulating the international classification. The society that was entrusted with the work most over-zealously declared the existing British classification to be the international classification. This so-called international classification showed scant respect to the age-old specialities of the other countries (there is not even any mention about the flowerpot dahlias in it). To this over-zealous act, a natural reaction took place in the advanced dahlia-growing countries. Three countries, America, Australia and New Zealand, revised their classifications of dahlias in the eighties. None of them have even mentioned about the so-called international classification. There is, however, a conscious endeavour on the part of the different countries to come as close to one another as practicable. But the idea

of an international classification has been practically dropped on finding it to be impractical. The so-called international classification and the reactions to it, however, have done us much good. We can now suitably modify the so-called international classification to make it a suitable one for this country.

As India always has the influence of the British classification the task of the Indian classification becomes easy. The two groups, Single-flowered dahlias and Paeony-flowered dahlias, are not likely to be popular here at any time, so the cultivars of these two groups may be conveniently put under the Miscellaneous Dahlias Group. And their places may be suitably occupied by Water Lily Dahlias and Fimbriated Dahlias since these two groups are likely to be highly popular in this country also. The following are complete ten groups of dahlia (except the two groups, all other retain their original group number) for exhibition for Indian exhibitions.

1. Water Lily Dahlias
2. Anemone-flowered Dahlias
3. Collerette Dahlias
4. Fimbriated Dahlias
5. Decorative Dahlias
6. Ball Dahlias
7. Pompon Dahlias
8. Cactus Dahlias
9. Semi-Cactus Dahlias
10. Miscellaneous Dahlias

Classification of dahlias for exhibition is directly connected with judging dahlias in the exhibitions, i.e. competitions. For judging Water Lily and Fimbriated groups, classifications of Australia and New Zealand are probably the best. And for judging flowers of the other eight groups, the British classification is probably the best for this country. All the above-mentioned groups, except for Collerette and Miscellaneous (certain types belonging to this group) groups, should have fully double flowers. An exhibit, i.e. flower, belonging to any of these fully double-flower groups, should not open its disc before judging at the exhibition. If the exhibit opens its disc prior to judging, it is liable to be disqualified. And 'Pompons' must not be more than 50 mm in diameter. For flowerpot dahlias, the balance between pot, plant and flower(s) is a very important factor.

Propagation and Preservation

Dividing sprouted field tubers and storing tubers after lifting are the usual methods for propagation and preservation respectively in hill areas. After the flowering is well over and before it frosts, the tubers

formed at the base of the dahlia plants are lifted. Two shovels (or spades) working together from the opposite sides of the field tuber is the best method to lift it. Tubers are dried in shade and then stored in a cool and dry place. The dahlia tubers go dormant (in plains they may not be dormant) in the winter of hill areas and they sprout spontaneously with the coming summer season. The sprouted field tubers are divided in such a way so that each division has one sprout and at least one tuber. The tuber divisions should be singly planted in 15-cm pots and conditioned before planting them in ground or flowerpots.

In the vast plains of India, the most satisfactory method of preservation is the late-cutting (discussed under *'India's Contributions to the World of Dahlias'*). Striking cuttings to make green plants is the usual method of propagation in plains. Dahlia cultivation in plains becomes a lot easier when it is done by transplanting green plants. A good cutting should be 6–8 cm long and 2–3 mm in diameter, and 2–3 cm of a cutting should remain inside the rooting medium. The base of the cuttings is made firm so that there may not be any movement for the portion inside the rooting medium. Coarse sand is usually used as the rooting medium, it has to be sterilized before use. After the insertion of the cuttings, the medium has to be kept moist all the time. The cuttings usually take two weeks to root. A rooted cutting is planted in an 8-cm pot and grown in it for seven days in order to make a green plant. Both green plants and conditioned tuber divisions are transplanted with their root ball intact. This is done by tossing them out of the small pots.

Quality Control

Planting materials, i.e. green plants, tuber divisions, etc. of a first-rate quality is a must for a real success in dahlia growing. Any double-flowering cultivars producing semi-double flowers should not be used for propagation (these are, if not virus affected, good as seed-bearing parents). Plants suffering from viral diseases are not capable of producing first-rate blooms. Any plant suspected to be suffering from a virus disease should be destroyed by burning forthwith. Aphids and thrips are carriers of virus diseases. These may be kept under considerable control by routine spray of some milder pesticides. In hill areas, tuber rot is a serious problem. Spraying Bavistin (1 g in 1 litre of water) immediately after lifting tubers, at the time of storing and immediately after tuber division is helpful. Charcoal rot is very much prevalent in Delhi area. Routine drenching with Captan (2 g in 1 litre of water) during summer and rainy seasons is a very effective help. Mites are a very serious problem almost everywhere in the vast plains. The drowning method (Swami Vinayananda, 1984) has been found to be most effective to combat mites.

Quality control also depends a lot on the types of cuttings. All shoots from stock plants (that are resultant of late-cuttings), tender shoots arising directly from tubers, and basal tender shoots from older plants make first-rate cuttings. Tender but not basal shoots from older plants always produce inferior cuttings and inferior flowers–this type of planting material has swamped the dahlia market in this country and a serious grower has to carefully avoid such green plants.

DAHLIA BREEDING

Dahlia breeding is probably the easiest of all. Capping and emasculation are pains-taking steps and the absence of these make dahlia breeding particularly easy. A good percentage of dahlia cultivars is self-compatible. Disc florets, almost as a rule, have both stigmas and stamens. And the ray florets (petals) also at times contain stamens. It is almost impossible to discover the stamens of the ray florets. But such occurrence of stamens is by no means common. Common or not, the presence of any stamen can very well upset the whole programme of capping. Emasculation of disc florets is practically impossible. In a self-compatible cultivar, the pollination is certain to take place even before the emasculation is attempted. And in self-incompatible cultivars, emasculation is nothing but superfluous. The capping, however, has some utility in the case of disc-floret breeding with self-incompatible seed-parent but the condensation inside the cover of a dahlia bloom is great and so one has to be very careful about it. Two methods of breeding are particularly useful for places where the breeding is done in the open. These are, the hand-pollination breeding (Bhikshu Buddhadev, 1976) that has been standardized by this author for the Indian climates and the induced bee-pollination. The hand-pollination breeding, however, seems to be the best for breeding this popular flower.

Hand-pollination. The dahlia petal (ray floret) is a complete female flower and the stigma is situated at the nner base of the petal. The stigmas of different cultivars have different shapes but the most usual form looks somewhat like a capital Y at the ready state of the stigma. When the petal fully opens the stigma also opens with that, and the pollination of the stigma starts on the day the petal is fully open. The hand-pollination is carried on with the help of a zero-numbered sleek painting brush (Fig. 3). This is done to as many ready stigmas as can be easily reached. Wherever possible, the same stigma is pollinated for three consecutive days, from the day the petal is fully opened, but the pollen-bearing parent need not be the same for all these days. It has been found that the rows of petals near to the disc bear seeds more easily. The withered petals of the seed-bearing flower are pulled out gently after fifteen days from the opening of the innermost row of petals. The

seeds ripen on the plants themselves, a process which takes around a month. The pollen is to be found at the disc of a dahlia flower, and it looks like yellow or orange cosmetic powder on maturity. On touching with the tip of the brush the pollen adheres to it. Pollen is available for days together from the same bloom. The honey bees are very much after the pollen but they show no interest in the stigmas at the base of the petals. This particular aspect makes capping of the flower irrelevant under this method of breeding.

Induced bee-pollination. This form of breeding is the oldest and there are also many votaries of this even among the modern breeders. This method is also the easiest of all. Actually speaking, a breeder has hardly anything to do beyond the planning in this method of breeding. Two cultivars are selected as parents (each may be seed-parent and pollen-parent at the same time) and they are planted in pairs, or only these two cultivars in a bed of their own, and cultivated in isolation as a part of the plan. The plants are kept in isolation, i.e. away from all other dahlia cultivars, so that they may not be influenced by the pollen of the other cultivars. Discs (disc-florets of the dahlia are usually bisexual) of both the parents should open (by taking several flowers on a plant this may be easily done) at the same time. The honeybees are always after the dahlia pollen, in their search for pollen they will effect a cross-pollination between the two parents. And thus both parents may produce seeds. If a cultivar is self-compatible, then self-pollinated seeds are the most likely outcome. This form of breeding is based on the assumption that all dahlia cultivars are self-incompatible. Since the overwhelming majority of cultivars seems to be self-incompatible, this method is worth trying though one should remember about its limitations.

The flower to supply pollen gives a lot of pollen if kept indoors as a cut flower. A seed parent should be encouraged by stopping to bear several flowers at a time. Moreover, seed-parents should get only the booster-feed and no bud-feed. In induced bee-pollination, you may expect seeds only at the disc. And in hand pollination, seeds may form both at the base of the floret-stigmas and at the disc, the latter being either self-pollinated or bee-pollinated seeds.

Seeds and seedlings. Seeds should be dried well in strong sun and stored well. Dahlia seeds lose viability very fast though an experiment by this author has clearly shown that a small percentage of seeds do retain their viability for one and a half years. Seeds produced in plains may be sown in hill areas almost immediately after drying them and *vice versa* this may be used advantageously and the final results obtained at the earliest. Dahlia seeds are sown like summer-annuals in hill areas and like winter-annuals in plains. The seed starts to germinate from the third day from the time

of sowing in plains but it takes a few more days in hill areas. The last seed to germinate from the same sowing may take many more days.

Wherever possible, seedlings are best grown in flowerpots as this offers certain additional advantages. One seedling to a 26-cm flowerpot is better than three seedlings to a 30-cm flowerpot. Seedlings are nurtured like flowerpot dahlias but they do not get any bud-feed nor any liquid feed. Lifting of tubers sometimes causes death of a plant, when a promising first-year seedling dies in this manner it becomes a total loss. Moreover, it is difficult to manipulate a plant in ground for producing basal shoots for late-cuttings. In the case of the first-year dahlia seedlings in flowerpots, they may continue in the pot or the tubers may be easily collected without causing any injury to it. Secondly, flowerpot first-year seedlings may be manipulated to produce basal shoots (to be taken as late-cuttings) immediately after the plant produced the first flower. The first-year seedlings to produce late-cuttings are kept prostrate with the main stem towards the sun. At the time of watering the flowerpots have to be raised but they are put in their previous position immediately after that. Keeping the plants in lying condition helps the basal dormant shoots to sprout and develop very fast and, as a result, there are plenty of suitable shoots for late-cuttings. All the different methods of preservation should be employed to perpetuate a promising first-year seedling. From the first-year seedling stage, preservation, propagation etc. are like that of the existing cultivars.

Dahlia seedlings may show improvements during the first three years. Most changes or improvements take place during the second year. Any seedling to be finally selected should be superior to the existing cultivar that resembles it most or should be at least equal to it.

FUTURE DEVELOPMENT OF DAHLIA

The progress of the dahlia in only 200 years (the dahlia came out of its native land in 1789) is indeed fantastic, but it has, by no means, reached the pinnacle. There is no blue dahlia, black (actually deep red but looking like black) dahlia or green (green chrysanthemums are extremely beautiful) dahlia. The fragrant dahlia is also a distinct possibility. And what about climbing dahlias? *Dahlia macdougallii* is the only climbing dahlia species and it can climb some 10 m. By breeding with it, there might be a series of beautiful climbing dahlias. Many more new forms are also likely to appear in dahlias. Dahlia has indeed to go miles before it reaches the pinnacle.

UNIQUE ROLE FOR INDIA TO PLAY

With dahlia breeding and commercial exploitation, certain development

centring dahlia in India can be taken as a foregone conclusion. These are: a National Dahlia Society with a great number of satellite dahlia societies; better organized dahlia shows, launching Indian cultivars etc. in the international market, besides a lot of research. The accomplishment of all these will surely place India among the top dahlia-growing countries. But India can do for the cause of dahlia a very great service which no other country can probably do.

The unique role that India can play is to develop a sanctuary for the original species of the dahlia in some suitable place in the Himalayas. The taxonomy of the dahlia contains 28 dahlia species and 4 intraspecific taxa (Sorensen, 1980) and these are still extant in their habitats in Mexico, Central America and northern-most South America. Though they are still existing they are also very much in danger because of the ever-spreading civilization. Moreover, it is not really easy to collect a particular species from its habitat for geographical, political and reasons otherwise. Dahlia cultivars and species (this author grew a species, *Dahlia imperialis*, this way at an altitude around 2,000 m in the Himalayas) grow in various parts of the Himalayas without getting any attention. *Dahlia* sp. growing in wild like their habitats, and occur in the Himalayas only. And this particular facet provides the right opportunity for India to play this unique role.

According to some specialists, the colour of the modern dahlias is already showing the sign of being washed-out. If this be true, the need will soon arise to back-cross (as is being done in rose breeding these days with sterling effects) with the original species. When the original species are easily available this and a lot of other researches should be on the cards. This sanctuary will indeed do dahlia and the dahlia enthusiasts a world of good. And the posterity will remain ever grateful for this unique service.

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7

Gladiolus

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GLADIOLUS, a bulbous ornamental, has gained popularity in many parts of the world owing to its unsurpassed beauty and economic value. It is grown for both cut flower and garden display purposes. It ranks next only to tulips in Holland in commercial importance. There are now a large number of varieties with different colours, types of florets and petal structure available in the world which have arisen as a result of interspecific and intervarietal hybridization. In India also, gladiolus has become one of the most important commercial flower crops. During winter season, cut flowers besides home consumption, can be exported to European countries as during this period it is difficult to grow gladiolus there outside and glasshouse cultivation is costly. In addition to cut flowers, corms can also be exported. Keeping all these facts in view, work on genetic improvement, cultural requirements and protection against diseases and insect pests of gladiolus was started at different research centres in India. The progress made so far on these aspects at different research centres is summarized below.

CROP IMPROVEMENT

Selection

Most of the present day varieties of gladiolus have been developed in countries like the USA,the UK, Holland and the USSR. Some of these varieties were introduced at different research centres in India and were evaluated for their suitability for different purposes on the basis of various characteristics under different agro-climatic conditions. At Regional Fruit Research Station, Mashobra (Shimla), the varieties 'Anne Virginia', 'Blaur Domino', 'Cardinal Spellman', 'Double Frills of Pink', 'Exotic Double Sister Eliz', 'Fenny Lind', 'Florence Nightingale', 'Gold Dust', 'Hawaii', 'Hill Crest', 'Kenny', 'King Lear', 'La Paloma', 'Mashobra No. 8', 'Oklahoma', 'Psittacinus hybrid', 'Rawi Fallu' and 'Spic and Span' were found to be promising.

Indian Agricultural Research Institute, New Delhi, reported eight varieties, namely 'Apple Blossom', 'George Mazure', 'Goeff Whiteman', 'Jo Wagenaar', 'Patricia', 'Pfitzer's Sensation', 'Ratna's Butterfly' and 'Snow Princess', to be most promising for Delhi conditions.

Thirty-one large-flowered varieties, namely 'Apple Blossom', 'Australian Fair', 'Blue Lilac', 'Camellia', 'Debonair', 'Fred Tucker', 'Friendship', 'George Mazure', 'Geliber Herald', 'Goeff Whiteman', 'Green Woodpecker', 'G.S. Porter', 'Jo Wagenaar', 'Lady Killer', 'Life Flame', 'Lincoln's Day', 'Old Gold', 'Oscar', 'Pactolus', 'Patricia', 'Prof. Goudrian', 'Ratna's Butterfly', 'Rose Spire', 'Sam Smith', 'Scheherazade', 'Snow Princess', 'Stormy Weather', 'Sylvia', 'Thunderbird', 'Vink's Glory' and 'Winter Gladioli', and six miniature varieties, viz. 'Canberra', 'Jolly Joker', 'Katrain Local', 'Mashobra Butterfly', 'Psittacinus hybrid' and 'Red Canna', were found to be outstanding for Shimla conditions at Indian Agricultural Research Institute, Regional Station, Flowerdale, Shimla.

At the Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, eleven varieties, namely 'Beauty Spot', 'Cherry Blossom', 'Friendship', 'Jo Wagenaar', 'Melody', 'Picardy', 'Snow Princess', 'Tintorente', 'Tropic Seas', 'Watermelon Pink' and 'Wild Rose', were found to be promising for cut flower and garden-display purposes.

Hybridization

Studies on floral biology were carried out at Bidhan Chandra Krishi Vishwa Vidyalaya, Kalyani, West Bengal. It was reported that the inflorescence of gladiolus is spike with sessile hermaphrodite florets. The flower buds take, on an average, 16 days to reach the full bloom stage. The opening of petals start early in the morning. It takes 22–24 hours for complete opening of flower. The dehiscence takes place between 8 and 9.30 A.M. following anthesis. The pollen grains were found to be round in shape with average diameter of 106 μ. Pollen stainability with acetocarmine was 98% and stigma remained receptive for 24 hours.

At IIHR, Hessaraghatta, Bangalore, about 6,000 hybrids were raised. Of these, nearly 2,010 were evaluated thoroughly for various characteristics for 2–3 seasons. Performance trials of very promising hybrids were conducted for three seasons in comparison with standard cultivars. Six hybrids were finally selected and released as 'Meera', 'Nazrana', 'Poonam' and 'Spana' in 1979 and as 'Aarti' and 'Apsara' in 1980. Brief descriptions of these new cultivars are given below.

'Meera'. It is from a cross 'G.P.1' × 'Friendship'. It flowers after 58 days of planting. Spikes are robust, bewitching and 90 cm long. Rachis length is 54.3 cm, florets snow white, 18 per spike, compact and thick-textured, open-faced, size 11.9 cm, 6 remain open at a time. Vase life of cut flowers is 8 days. Cormel production is very good. It is ideal for cut flower and garden-display (Fig. 1).

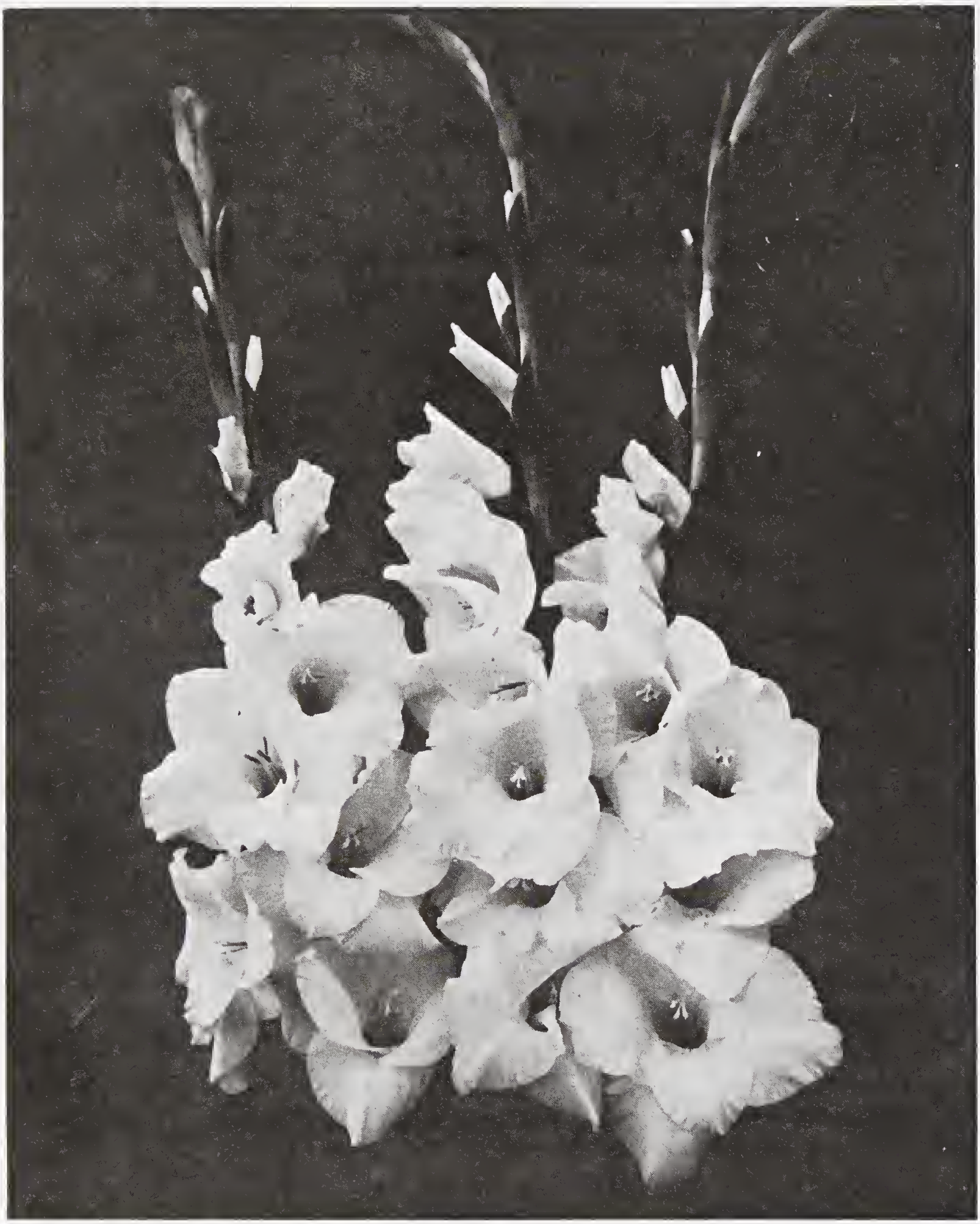


Fig. 1. 'Meera' ('G.P. 1' × 'Friendship').

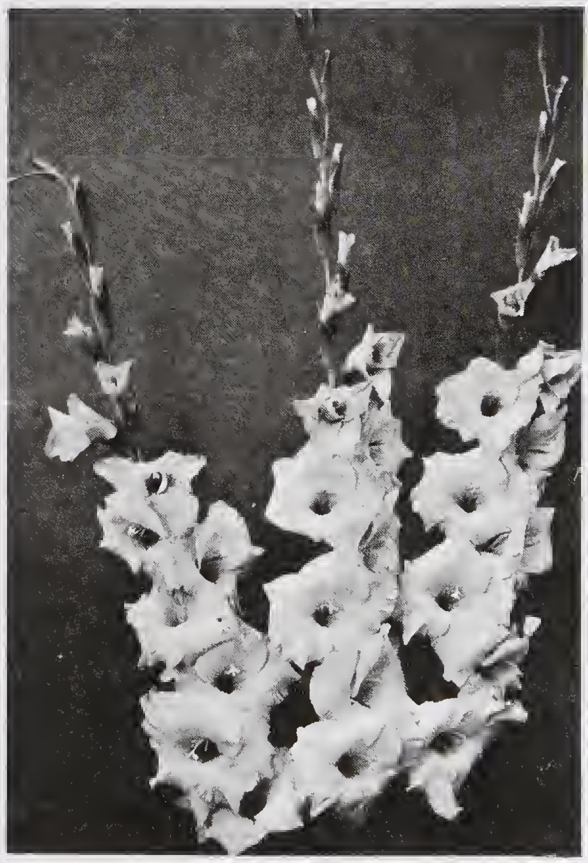
'Nazrana'. This hybrid is from a cross 'Black Jack' × 'Friendship'. It produces flowers 57 days after planting. Spikes are very strong, charming and 104.6 cm long. Rachis length is 64.5 cm. Florets are cardinal red (53.B) with Barium Yellow (10.D) flash in throat, 18 per spike, compact and thick-textured, open-faced, size 11.5 cm, 6 remain open at a time. Cut flower life is 6 days. Cormel multiplication is good. It is suitable for cut flower purpose (Fig. 2).

'Poonam'. It is from a cross 'Geliber Herald' × 'R.N. 121'. It flowers after 61 days of planting. Spikes are 98 cm long. Rachis length is 61.7 cm. Florets are Dresden Yellow (5.D) with Mimosa Yellow (8.C) blotch, 17 per spike, texture medium, open-faced, size 11 cm, 6 remain open at a time. Cut flower life is 7 days. It is excellent multiplier. It is tolerant to *Fusarium* wilt disease. It is good for cut flower and garden-display purposes.

'Sapna'. This hybrid is from a cross 'Green Woodpecker' × 'Friendship'. It requires 54 days to flower. Spikes are strong, magnificent and 83 cm long. Rachis length is 51.7 cm. Florets Barium Yellow (10.D) with Primrose Yellow (4.A) blotch and Mandarin Yellow (41.D) tinge on margins, 17 per

Fig. 2. 'Nazrana' ('Black Jack' × 'Friendship').

Fig. 3. 'Sapna' ('Green Woodpecker' × 'Friendship').



spike, compact and thick-textured, open-faced and ruffled, size 12 cm, 8 remain open at a time. Cut flowers last for eight days in vase. Cormel multiplication is excellent. Very good for cut flower and garden-display purposes (Fig. 3).

'Aarti'. Is is from a cross 'Shirley' × 'Melody'. Requires 70 days to flower. Spikes are attractive and 63.6 cm long. Rachis length is 48.4 cm. Florets Poppy Red (40.D) with reddish purple (60.A) and Canary Yellow (9.C) blotch and Mandarin Red (40.C) spots, 11 per spike, hooded, size 10.8 cm, 4 remain open at a time. Cut flower life is 6 days. Cormel multiplication is very good. Butterfly type, suitable for flower arrangement.

'Apsara'. This hybrid is from a cross 'Black Jack' × 'Friendship'. It flowers 45 days after planting. Spikes are strong, dazzling and 97.6 cm long. Rachis length is 67 cm. Florets are Ruby Red (61.A) with Barium Yellow (10.D) flecks in throat, 18 per spike, thick-textured, open-faced, size 11.3 cm, 6 remain open at a time. Cut flower life is 8 days. Cormel multiplication is good. Suitable for cut flower purpose (Fig. 4).

Three cultivars were developed and released as 'Agni Rekha', 'Mayur' and 'Suchitra' by Indian Agricultural Research Institute, New Delhi, in 1980. They are briefly described below.

'Agni Rekha'. It is an open-pollinated seedling of cv 'Sylvia'. Maturing in mid-season. Plants are 90 cm tall. Florets are Fire Red (10) with Saffron Yellow (7/2) blotch and scarlet stripes, 18 per spike, open- aced, size 9.8 cm. Cormel multiplication is good. It is suitable for cut flower purpose.

'Mayur'. It is also an open-pollinated seedling of cv 'Sylvia'. It is late flowering. Plants are 82 cm in height. Florets Lilac Purple (31/3) with dark purple throat (31), 20 per spike, open-faced, size 9.5 cm. Cormel multiplication is very good. It is suitable for cut flower and garden display purposes.

'Suchitra'. This hybrid is from a cross 'Sylvia' × 'Jo Wagenaar'. Plants are 90 cm tall. Florets are Camellia Rose (622/2) with stripes of Vermilion (18) and Dianthus Purple blotch, open-faced, 22 per spike, size 9.6 cm. It is good for cut flower purpose.

National Botancial Research Institute, Lucknow, developed and released 11 cultivars, namely 'Manmohan', 'Manohar' and 'Mukta' in 1982; 'Manhar', 'Manisha', 'Mohini' and 'Jwala' in 1983 and 'Archana', 'Arun', 'Sanyukta' and 'Triloki' in 1984. Their brief descriptions are given below.

'Manmohan'. This hybrid is from a cross 'Friendship' × *Gladiolus tristis*. It blooms 80–120 days after planting. Spikes are one-sided and 80 cm in length. Florets Primrose Yellow (601/3) having irregular splashes of Orchid Purple (31/1) at the tips of outer 3 petals, throat Primrose Yellow (601/3) having splashes of Orchid Purple (31/1) in irregular fashion, overlapping, 14–16 per spike, size 10 cm. Cormel production is very good.

'Manohar'. It is also developed from the cross 'Friendship' × *G. tristis*. Flowers 80–120 days after planting. Spikes are one-sided and 80 cm long. Florets Orchid Purple (31/2) and at tips Orchid Purple (31/1) with Primrose Yellow (601/3) throat and all the petals have a central streak of Primrose Yellow (601/2) and reverse side with splashes of Orchid Purple (31/1) and Primrose Yellow (601/3), 14–16 per spike, size 10.5 cm. Cormel multiplication is very good.

'Mukta'. This hybrid is also from the cross 'Friendship' × *G. tristis*. Flowers 90–120 days after planting. Spikes one-sided and 70 cm in length. Florets are Sulphur Yellow (1/3) with Sulphur Yellow (1/2) throat and reverse side Sulphur Yellow (1/3) with splashes of Orchid Purple (31/2) in irregular fashion, loosely placed, 12–15 per spike, size 9 cm. Production of cormels very good.

'Manhar'. It is also developed from the cross 'Friendship' × *G. tristis*. It requires 80–120 days to flower. Spike length is 60 cm. Florets are Primrose Yellow (601/3), tips of outer 3 petals splashed with Tyrian Rose (24/1), throat Primrose Yellow (601/1), reverse side Primrose Yellow (601/3)

Fig. 4. 'Apsara' ('Black Jack' × 'Friendship').

Fig. 5. 'Shobha' (Mutant of 'Wild Rose').

having splashes of Tyrian Rose (24/1) on outer 3 petals in an irregular fashion, 14–18 per spike, size 10 cm. Cormel production is good.

'Manisha'. This hybrid is also from the cross 'Friendship' × *G. tristis.* It flowers after 80–120 days of planting. Spikes are 60 cm long. Florets are white, outer 3 petals splashed with Tyrian Rose (24/3), more towards margins, throat Primrose Yellow (601/2), reverse side white, irregularly splashed with Tyrian Rose (24/2), 14–16 per spike, size 11 cm. Cormel production is very good.

'Mohini'. It is also derived from the cross 'Friendship' × *G. tristis.* It requires 80–120 days to flower. Spikes are 60 cm long. Florets are white, outer three petals and inner upper one petal heavily splashed with Tyrian Rose (24/2 and 24/3), lower inner two petals sparsely splashed with the same, throat Primrose Yellow (601/3), reverse white splashed with Tyrian Rose (24/2 and 24/3) in an irregular fashion, 12–14 per spike, size 10 cm. Cormel production is very good.

'Jwala'. A new cultivar bearing Vermilion flowers. A special feature of it is its branching habit which makes it especially suited for bedding purpose.

'Archana'. This hybrid is from a cross *G. psittacinus* 'Sylvia' × 'Friendship'. It requires 90–120 days for flowering. Spikes are 80 cm long with branching habit. Florets are Begonia (619/1) suffused with Begonia (619) with a central white streak on petals, blotch Primrose Yellow (601/2), reverse same, 16–18 per spike, ruffled, size 11 cm. Cormel multiplication is good.

'Arun'. It is developed from a cross *G. psittacinus* 'Sylvia' × 'Fancy'. It requires 90–120 days for flowering. Spikes are 80 cm long and branched. Florets Vermilion (18/2), splashed and streaked towards margins of petals (18/1), inner lower two petals having a streak in centre, half Primrose Yellow (601/1) and half Cardinal Red (822/3), reverse side same, 16–18 per spike, size 10 cm. Cormel multiplication is good.

'Sanyukta'. This hybrid is obtained from a cross 'Friendship' × *G. tristis.* It requires 90–120 days for flowering. Spikes are one-sided, branched and 80 cm long. Outer three petals of florets Rose Opal (022), inner three petals Rose Opal (022/2), throat Primrose Yellow (601/3), reverse side Rose Opal (022/2) splashed with Primrose Yellow (601/3) more on the lower side, 18–20 per spike, over-lapping, size 10 cm.

'Triloki'. It is also developed from the cross 'Friendship' × *G. tristis.* Flowers after 90–120 days of planting. Spikes one-sided and 75 cm long. Florets are China Rose (024) in upper half portion, Primrose Yellow (601/2) in lower half portion having splashes of China Rose (024) on the margins, reverse same, 14–15 per spike, size 10 cm. Cormel production is very good.

Four very promising hybrids, 'Chaubattia 6/4', 'Chaubattia 14/23',

'Chaubattia 19/1' and 'Chaubattia 21/10' were selected for trial by Horticultural Experiment and Training Centre, Chaubattia, Uttar Pradesh.

IARI, Regional Station, Flowerdale, Shimla, produced nine promising hybrids. They were numbered as '71 SJW-Or 074-4', '71 SJW-PfS 173-6', '71 SJW-PfS 273-7', '71 SJW-PfS 373-9', '71 SPfS-SS 073-14', '71 SPfS-JJI-273-15', '71 SSSm-PfS 073-22', '71 SRB-JJI-374-26' and '71 SHE-GG 074-31'.

At NBRI, Lucknow, intra- and interploidal crosses (using tetraploid, triploid and diploid hybrid and garden cultivars) and one interspecific cross (*Gladiolus* sp.cv 'La Paloma' × *Gladiolus callianthus*) were made. It was observed that 4x × 2x cross was successful only when a tetraploid was used as a female parent. Twenty eight out of 29 plants were triploid in the progeny of the cross 4x × 2x. *Gladiolus callianthus* could be crossed only with the cvs 'La Paloma' and 'Pacifica' (2n=60)when these were used as female parents. *G. psittacinus* hybrid (5x) and garden cultivars (4x) could be crossed reciprocally.

Mutation Breeding

At IIHR, Hessaraghatta, Bangalore, corms of three cultivars of gladiolus were irradiated with gamma rays at different doses. LD_{50} was found to be between 10 and 15 Kr. A desirable and stable mutant with Shell Pink floret colour, observed in vM_2 generation as a chimera in 1 Kr treatment, was isolated from the cv. 'Wild Rose' with Roseine Purple floret colour in vM_4 generation. Based on the result obtained in performance trials, this mutant was named and released as 'Shobha' in 1980. Its brief description is given below.

'Shobha'. It is a mutant of cv 'Wild Rose' induced with gamma rays at 1 Kr. It requires 50 days for flowering. Spikes are pleasing and 97 cm long. Rachis length is 62 cm. Florets Shell Pink (37.C) with Empire Yellow (11.D) throat, 18 per spike, medium-textured, open-faced, size 11.5 cm, 6 remain open at a time. Vase life of cut flowers is 7 days. Cormel multiplication is good. It is ideal for cut flower and garden decoration purposes (Fig. 5).

IARI, Regional Station, Flowerdale, Shimla induced flower colour mutations after treatments with gamma rays in gladiolus cvs 'Jo Wagenaar', 'Oscar' and 'Picardy'.

Cormels of gladiolus cv 'Scarlet Double' were subjected to different levels of fast neutron and gamma radiation at Bhabha Atomic Research Centre, Bombay. It was reported that the gladiolus cormels were less sensitive to irradiation and survival at higher doses was greater than for other bulbous ornamentals. Fast neutron treatment was more effective.

Genetical Studies

Studies on genetic variability, interrelationship of characters and selection index in gladiolus were carried out at IIHR, Hessaraghatta, Bangalore. The range,

coefficient of variation, phenotypic and genotypic coefficient of variation, heritability in broad sense and genetic advance as percentage of mean were all high for three characters, namely, weight of cormels produced per corm, number of cormels produced per corm and weight of corms produced. Thus, selection based on these characters will be very effective for the improvement of the crop. Spike length was significantly correlated in positive direction with rachis length, number of florets per spike, weight and size of corms produced and breadth of leaves. Number of florets per spike was positively correlated with rachis length, floret size, weight and size of corms planted and weight of corms produced. Floret size showed significant positive correlations with weight and size of corms planted, whereas its association with days to flowering and number of corms produced was significant and negative. Weight of corms produced had significant positive association with breadth of leaves. Selection index studies revealed that rachis length was the most important character to be used in selection.

CROP PRODUCTION

Manuring

In 2-year trials conducted at NBRI, Lucknow, plants of gladiolus cv. 'Psittacinus hybrid' were applied with urea (25–100 g/m^2), P_2O_5 (100–300 g/m^2) and K_2O (100–300 g/m^2) in various combinations. In general, NPK application delayed spike emergence and number of buds per spike was not appreciably affected by NPK. Flower spikes were tallest (126.5 cm) in plants which received 25 g urea + 100 g P_2O_5 + 100 g Ko/m^2. Another experiment was conducted at this Institute to find out the effect of nitrogen on the growth, flowering and corm/cormel yield in cv 'Psittacinus hybrid'. Potash at 200 kg/ha as KCl and phosphorus at 200 kg/ha as single superphosphate were given at the preparatory stage. Nitrogen at 0, 50, 100, 150 and 200 kg/ha was used. Half of the nitrogen doses were applied initially and the other half 30 days after planting. The results indicated that N alone has not shown significantly better results as compared to control in its immediate growth, flowering and corm/cormel yield. There was increased nitrogen uptake under enhanced nitrogen application, 200 kg/ha being most effective. It was suggested that enhanced nitrogen is stored up in the corms for use in the subsequent generation.

In studies with gladiolus cv 'Friendship' at IIHR, Hessaraghatta, Bangalore, plants with pinched and non-pinched flower spikes were given a basal dressing of 2 kg FYM/m^2 + 4 g P_2O_5 and 6 g K_2O per plant + N at 5, 10, 15 or 20 g/m^2. Average corm and cormel weight rose with increasing N rates in both pinched and non-pinched treatments, but was greater in pinched treatment. The average number of cormels per plant was 59.31 in pinched

treatment at 5 g N/m^2 followed by 59.01 in non-pinched treatment at 10 g N/m^2. The lowest figure (43.21) was obtained in pinched treatment at 15 g N/m^2. The heaviest (61.03 g) corms were produced with 20 g N/m^2 in pinched treatment. The number of cormels produced per plant was not significantly affected by N or pinching treatments.

At Botanical Survey of India, Calcutta, plants of cv 'Friendship' were top-dressed with 5 levels of N (0, 10, 15, 20 and 25 g/m^2), 3 levels of P (0, 15 and 30 g/m^2) and 3 levels of K (0, 15 and 30 g/m^2). Increasing levels of N advanced the time of flowering and greatly increased flower spike length, corm weight and size and number of cormels per plant. The maximum number of florets per spike and the largest flowers were obtained with 20 g N/m^2. The application of P and K and rising levels of each element tended to improve the flower spike quality, corm growth and cormel production. First and/or second order interactions were found between floret number per spike, flower diameter, corm weight and corm size.

It was reported from BCKVV, Kalyani, West Bengal, that the application of nitrogen at the rate of 50 g/m^2 along with phosphorus at 10 g/m^2 and potash at 20 g/m^2 gave the highest yield of flowers and corms in gladiolus cv 'Oscar'.

Nutritional and plant population studies conducted at Marathwada Agricultural University, Parbhani, Maharashtra, on cv 'H.B. Pitt', showed that the height of plant increased by 50 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha. The positive effect of N was enhanced in the presence of P. Comparative response of N was greater at 30 cm × 30 cm. Positive significant influence was exerted by 50 kg N/ha and 30 cm × 45 cm spacing on leaf breadth and stem size. A dose of 100 kg N + 50 kg K_2O/ha produced significantly more number of cormels per plant and hectare basis. The number of florets and the length of spike increased with increasing N from 0 to 100 kg/ha. A dose of 50 kg P_2O_5 was also superior to control. The response of N accentuated at the wider spacing and by the application of P and K. The number of corms per plant increased by the application of N and K and the wider spacing. Number of corms per hectare increased by N and K application and closer spacing (30 cm × 30 cm). Interaction of N × P, was consistent with regard to corm number per hectare. The effect of P was seen through the interaction with N or K or N and K both. The optimum levels of fertilizer and spacing based on the results of this experiment were 100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha and 30 cm × 30 cm spacing.

Effect of Time of Planting, Depth of Planting, Spacing and Pinching on Production of Flowers and Corms

At IIHR, Hessaraghatta, Bangalore, effect of planting time on growth,

flowering and corm production was studied in gladiolus cv 'Friendship'. Planting in June, October and November proved to be the best so far as quality (length of rachis and spike and number and size of florets) of flower was concerned. Planting from December to February also appeared to be good for flower production. Planting during August, September, March and April did not appear to be very congenial for production of flowers. Maximum number of cormels were obtained from planting in June followed by February, April and May plantings. Corms planted in June took minimum number of days (61.70), while those planted in February took maximum number of days (93.30) to flower. The results indicated that higher temperature increased plant height and longer day-light hours delayed spike appearance, increased spike length and number of florets. Higher soil moisture content increased spike length and floret number. In another experiment at this Institute, effect of corm size, depth of planting and spacing on the production of flowers and corms was studied in cv 'Fr endship'. There were three corm sizes (1.5–2.5 cm, 2.5–3.5 cm and 3.5–4.5 cm). three depths of planting (3, 5 and 7 cm) and three spacings (15, 20 and 25 cm), It was observed that larger corms increased the height of plants significantly. Increased planting density resulted in shorter rachis with less number of small-sized florets. In one case, wider spacing increased the duration of flowering under field conditions. Shallow planting increased, while deep planting reduced the number of cormels produced per plant. The interaction between wider spacing and shallow planting produced significantly heavier cormels as against deep planting. An experiment on the effect of removal of leaves, flowers and rachis on the production of corms in cv 'Friendship' was conducted at the above Institute. Flower spikes were removed at different stages of opening either without leaves or along with two or four leaves. In a couple of treatments, the rachis was retained after removal of florets before opening or after half the florets were opened. It was observed that, in general, the corm size and weight increased when the spikes were removed before opening of the florets or after 2, 4 or half the number of florets opened either singly or along with 2 leaves compared to control (where the spike was retained) and when spike was cut after all the florets had opened. The retaining of rachis but removal of florets adversely affected the corm production. The spike removal treatment has no effect on the cormel production.

At National Bureau of Plant Genetic Resources, Regional Station, Phagli, Shimla, the effect of different planting depths (4, 7 and 10 cm) on corm and cormel production was studied in gladiolus cv 'Sylvia' and in a hybrid ('Sylvia' × 'Ratna's Butterfly'). Both corm and cormel production appreciably decreased with increased planting depth.

At BSI, Calcutta, research was carried out on the effect of corm size, planting depth and spacing on flowering and corm production in cv 'Friendship'. Corms of three sizes (2.5–3.5 cm, 4.0–5.0 cm and 5.5–6.5 cm) were planted at three depths (5, 7 and 9 cm) and three spacings (15, 20 and 25 cm) within the rows which were 20 cm apart. As corm size increased, so did the flower spike length, floret number, floret diameter and the size and weight of the corms lifted. A combination of shallow planting and medium corm size resulted in the maximum cormel production. As planting depth increased, the quality of flower spikes and daughter corms improved. Wide spacing was associated with the best flowering, corm growth and cormel formation. First and/ or second order interactions were found for all characters except flower size.

Effect of planting time on flower and cormel production was studied at Punjab Agricultural University, Ludhiana, in six cultivars of gladiolus. Small, medium and large corms were planted in mid-August, mid-September and mid-October. Large corms and early planting generally resulted in the earliest colour break of the basal floret. Cormel production was highest from large- and medium-sized corms planted in mid-October but great varietal differences were observed, 'King Lear' being the most productive.

Studies were conducted in Alokudyog Farm, New Delhi, on the effect of removal of flower and foliage on the yield of corms and cormels in cv 'Debonair'. Flower spikes alone or with leaves were removed at five growth stages, viz. before flower opening or when 2, 4, 8 or all flowers were open. Removal of spikes alone during the first three stages resulted in increase of corm weight from 124 g in control to 145–151 g in treatments. Removal of two leaves at these stages had an adverse effect on corm weight. There was no effect of these treatments on the weight of corms produced in the subsequent season. All treatments had an adverse effect on the production of cormels, which was highest in the control (60/plant).

Effect of growth regulators

Investigations conducted at NBRI, Lucknow, indicated that IAA and IBA concentrations of more than 50 ppm had a negative effect on corm sprouting and survival in *Gladiolus psittacinus*. The best results with regard to sprouting (100%), plant survival (100%), time taken to sprout (8.17 days), days to flowering (92.85 days), duration of flowering (16.21 days), spike length (59.95 cm) and number of florets per spike (14.6) were obtained with NAA at 50 ppm. Number of cormels produced per plant (9.2–10.8) was highest in plants treated with NAA at all concentrations (50, 100, 200 or 500 ppm).

At IIHR, Hessaraghatta, Bangalore, corms of gladiolus cv 'Friendship' were soaked for 24 hours in ethrel solutions of 50, 100, 250, 500 or 1000 ppm. The results obtained showed that soaking of cormels with ethrel had

very little effect on growth and flowering. However, ethrel soaking slightly reduced the length of flower stem, though the result was not significant statistically. The yield and weight of cormels increased significantly as a result of ethrel treatment.

Research was carried out at Panjab University, Chandigarh, to study the effect of GA_3 at different concentration (50, 100 or 200 ppm) in cv 'Sylvia' on growth, flowering and production of corms and cormels. It was found that spraying of GA_3 increased plant height and number of leaves and shoots per plant and improved spike quality (in terms of number and size of florets). The number and quality of corms and cormels produced were also enhanced by spraying. In most cases, 100 ppm applied three times was the most effective spray treatment. The maximum number of corms and cormels resulted from either a three-fold GA_3 spray or a preplanting dip at 100 ppm + spraying at 100 ppm at 30-day intervals.

Propagation in vitro

At PAU, Ludhiana, callus tissue cultures were established from excises segments of the inflorescence, flower stalk, denuded flower bract, perianth and leaf of two gladiolus cvs 'Oscar' and 'Snow Princess'. The best callus was obtained from segments of flower stalk cultured on a basal Murashige and Skoog medium supplemented with NAA and Kinetin. The callus mostly underwent rhizogenesis and occasionally differentiated some shoots. Complete plants were regenerated from *in vitro*-cultured cormels, cormel tips and axillary buds and six plants were formed from the segments of one cormel.

Dormancy

At IARI, Regional Station, Flowerdale, Shimla, an investigation was conducted, wherein the tunics from the cormels of gladiolus cv 'Little Mexicana' and two hybrids were either removed by hand or left intact to study their effect on sprouting of cormels. Skinned cormels sprouted much sooner and all of them sprouted. The average corm and cormel number per plant, weight of fully developed corms and percentage of plants that flowered were also higher in skinned cormels in comparison to cormels with intact tunic.

In a similar experiment at BARC, Bombay, effect of descaling was studied on the dormant corms of cv 'Happy End'. Descaling helped in faster sprouting than the controls. The mean time taken for the sprouting of descaled corms was, in general, less than the time taken for the sprouting of controls. It varied over 4–8 days between 25 and 100% sprouting. The plants from descaled corms exhibited vigorous growth in terms of larger leaves. A significant difference in the leaf number was observed at 10 weeks after

planting. Descaling proved to be favourable for producing flowers earlier as well as for availability of pickable spikes. Total flowering time (from planting till the stage of availability of pickable spikes) was 107 days in the case of descaled corms and 124 days in case of controls. In another experiment conducted at this Centre, effect of 6-Benzyladenine (BA) and ethrel on sprouting of cormels of gladiolus cv 'Scarlet' produced in summer and the rainy season was studied. Concentrations of BA ranged from 10 to 5,000 ppm, while those of ethrel ranged from 100 to 10,000 ppm. Summer crop cormels exhibited greater rest period than the rainy crop cormels. While presoaking in BA could break the dormancy of cormels of both the seasons, ethrel did so only on summer crop cormels. Also, the summer cormels responded to treatments more favourably than the rainy crop cormels, BA being always more effective than the ethrel.

In further investigation at this centre to find out the Benzyladenine-induced physiological changes in gladiolus cormels during dormancy, dormant cormels of gladiolus cv 'Scarlet' were descaled and soaked in 500 ppm solution for 30 minutes and were stored in moist sand. The cormels were taken out periodically for various examinations till the stage of sprouting. Benzyladenine-induced promotion of growth and release of dormancy of dormant buds was attributed to an increase in amylase activity as also to a rise in starch breakdown, level of sugars and consequently, respiratory activity.

At Horticultural Experiment and Training Centre, Chaubattia, Uttar Pradesh freshly harvested corms of cv 'Cremlin' were treated with GA (100 or 200 ppm) or Thiourea (500 or 1000 ppm) for 12 or 24 hours or the corms were chilled at 2° C for 15, 30, 45 or 60 days. The best flowering (100%) was obtained after treatment with Thiourea at 500 ppm for 24 hours followed by 95.6% with Thiourea at 1000 ppm for 12 hours. Flowering in control was 56.6%. Chilling treatments gave only 30–40% flowering.

At IIHR, Hessaraghatta, Bangalore, 10 cytokinin-like substances termed as X_1, X_2, X_3, X_{4a}, X_{4b}, X_{5a}, X_{5b}, X_6, X_7 and X_8 active in soybean hypocotyl test were detected in corms of gladiolus cv 'Friendship'. The factors X_{4a}, X_{5a} and X_6 were tentatively indentified as zeatin (Z), isopentenyl adenosine (iPA) and isopentenyl adenine (iP), respectively based on their behaviour during chromatographic analysis. Factor X_3 which behaved like zeatin riboside (ZR) in the above systems could be ZR and/or dihydrozeatin riboside (DHZR). The behaviour in Sephadex and ion-exchange column chromatography suggested that X_1 and X_2 may be cytokinin glucosides and X_8 a cytokinin nucleotide or a cytokinin conjugate similar to lupinic acid. The total cytokinin content and the concentration of Z, ZR/DHZR and iPA were higher in non-dormant than in dormant corms. The concentrations of X_1 and X_2 were higher in dormant corms of gladiolus.

Weed Control

Trial conducted in gladiolus at IIHR, Hessaraghatta, Bangalore, showed that Basalin at 2.1 kg/ha was the safest and effective herbicide as far as weed control and yield of spikes and corms were concerned. Yields were lower under Lasso and Sencor treatments and the latter had visible phytotoxic effects.

At Marathwada Agricultural University, Parbhani, Maharashtra, it was reported that Linuron at 1 kg/ha applied 24 days after planting gladiolus corms on Vertisol during rainy season caused no injury to plants grown for flower production. The treatment gave fairly good weed control and did not appreciably affect most of the growth and flower attributes. It increased leaf length and breadth and girth of the stem. The weeding operation was difficult during rainy season and was also less economical than Linuron application.

CROP PROTECTION

Diseases and Their Control

At the University of Allahabad, Uttar Pradesh the causal organism of a dry rot of gladiolus corms was identified as *Fusarium solani.* Rotting was reduced by treating the corms with 0.5% Flit-406, which was the most effective of 14 fungicides tested on a laboratory scale. Low temperature at storage and care in handling and harvesting were also recommended as means of reducing the risk of infection.

IARI, New Delhi, recommended dipping of gladiolus corms in solution of 0.05% of Aureofungin for one hour before planting for controlling the rotting of corms. Two sprays of the antibiotic, one at six-leaf stage and another 20–30 days before lifting the corms from the ground when the foliage of plants is still green, were also suggested.

NBRI, Lucknow, reported core rot caused by *Penicillium funiculosum* and a storage rot caused by *P. gladioli* for the first time in India in 1970. A soft rot disease caused by a bacterium *Erwinia carotovora* (Jones) Holland was reported to cause rotting of corms in *G. callianthus* from IARI, Regional Station, Flowerdale, Shimla, for the first time in India in 1976. Two more diseases such as 'Cork-screw' and 'Green-petal stunt' were reported to affect gladiolus from the same Research Station. It was supposed that these two diseases may be due to 'aster yellows' which has been attributed as a cause of similar disease in the U.S.A. and the U.K. In an experiment conducted at the above Research Station, several fungicides were compared for control of *Alternaria* spp., *Curvularia trifolii* and *Septoria gladioli* in gladiolus cv 'Vink's Glory'. The best control was

obtained with Dithane M-45 (Monocozeb) and Miltox (Copper oxychloride + Zineb) each at 0.2% sprayed at 2-week intervals from mid-June to October.

An outbreak of a new leaf-spot disease was observed in gladiolus cv 'Sylvia' for the first time in 1979 at C.S. Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. The disease generally affected the leaves at maturity. Initial symptoms appeard on leaf margins as irregular to circular, dirty whitish lesions like a chemical incrustation which coalesced and extended more towards midrib regions, later progressed from tip downwards to cover entire lamina. Straw-coloured bands also appeared in between the affected leaf area. Yellowing and twisting of the leaves and reduction in spike size also occurred in severe infection of the disease. It was also observed serious as root and neck rot on plants of gladiolus. The pathogen was identified as *Rhizoctonia solani* Kühn.

At IIHR, Hessaraghatta, Bangalore, 41 gladiolus cultivars and 14 hybrids were screened for resistance to wilt and cormel rot (*Fusarium oxysporum* f. sp. *gladioli* Snyder & Hansen) by inoculating cormels. Two cultivars, 'Australian Fair' and 'Mansoer' were found to be tolerant.

Insects Pests and Their Control

Investigations conducted at Vegetable Research Station, Katrain, Himachal Pradesh on the attraction of *Thrips flavus* to different colours in 22 cvs of gladiolus showed that bright red flowers were the most preferred and white ones were the least.

In an experiment conducted at IARI, Regional Station, Flowerdale, Shimla, for controlling cutworm (*Agrotis segetum*) in gladiolus, Methyl parathion at 0.02% was found to be the most effective. Quinalphos at 0.038% was almost as effective as Methyl parathion, but Chlordane at 0.07 or 0.14% was less effective.

CROP UTILIZATION

Maturity Standard for Corms

Investigations were carried out at NBRI, Lucknow, on vegetative growth, development and maturation of daughter corms of *Gladiolus psittacinus* hybrid (carrot red). It was concluded that these processes including maturation of daughter corms and cormels get completed 90 days after blooming under sub-tropical conditions.

Vase Life

Studies conducted at IIHR, Hessaraghatta, Bangalore, indicated that aluminium sulphate at 0.1% was an adequate substitute for 8-hydroxyquinoline in prolonging the vase life of gladiolus.

Experiments conducted at BCKVV, Kalyani, West Bengal, showed that vase life of cut flowers of gladiolus cv'Psittacinus hybrid' can be increased by use of growth substances like MH, CCC and B-nine. It was reported that vase life was significantly increased by MH at 150 and 300 mg/litre and B-nine at 150 and 600 mg/litre concentrations. CCC proved to be less effective than other two chemicals. The chemicals also improved the lustre of the individual flowers.

At Marathwada Agricultural University, Parbhani, Maharashtra, gladiolus cv 'H.P. Pitt' was grown in plots receiving different NPK conditions. The cut spikes were placed for 10 days in water or in a preservative solution containing 6% sucrose + 650 ppm $Al_2(SO_4)_3$ + 50 ppm $AgNO_3$. Vase life was longest in spikes from plots receiving N at 100 kg/ha, but no P and K, and held in the preservative solution.

Post-harvest Studies on Bud Opening

In an investigation carried out at Delhi University, Delhi, gladiolus spikes harvested at green-bud stage were placed in solutions of GA (10^{-4}M or 10^{-5}M) or sucrose either alone or together or in water (control), with illumination for 14 hr/day (set A) or they were kept in cardboard boxes in the dark at 4° or 20°C (sets B and C, respectively) for one week before being transferred to similar test solutions at 20°C. Flowers in set A had the highest percentage of open flowers, assessed after 15 days, varying from 58% for control to 84% for sucrose + GA (10^{-4}M) treatment. Flowers in set B given this treatment also had 84% open flowers, but other treatments were less effective than their counterparts in set A. Flowers in set C were already about 33% open when transferred to test solutions and treatment effects, assessed after only 10 days, differed little from controls (49% open). In second experiment at Delhi University, a critical stage in flower bud growth in the spikes of *G. natalensis*, initiated by GA_3 and sustained by sucrose, was identified. It corresponded to the stage at which the separation of outer bract occurred. In buds at different developmental stages, isolated and held in water, it was the same bud stage that first showed increased growth, irrespective of treatment. Buds not induced by light responded more significantly to GA_3 and sucrose than those induced by light. Since the separation of outer bracts resulted in light-induced amylase production and starch hydrolysis leading to petal growth, it is proposed that growth promotion by GA_3 is related to light-induced petal growth at this specific stage. In third experiment at the above University, it was observed that in the tight-bud spikes of gladiolus, the buds were nearly twice as heavy as younger green-bud spikes and had higher sugar and starch contents. About 50% of the flower buds opened in the green-bud spikes held in water compared with 67.5% in the tight-bud spikes. The flowers from the green-bud spikes were smaller and less intensely

coloured. When green-bud spikes were held continuously in sucrose (0.5 M), 75.3% of the buds opened. The peduncle did not elongate between the green-bud and the tight-bud stages, but the flowering axis elongated, so that the spikes of desired length could be harvested. A sucrose + GA treatment produced a spike length comparable to that obtained in the field. Storage of spikes in cardboard containers for 24 hours followed by transfer to water markedly increased fresh weight. An after-storage treatment with sucrose for 48 hours followed by transfer to water induced nearly 75% of buds on the green-bud spikes to open.

8

Bougainvillea

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WITH its spectacular mass of brightly coloured bracts, the *Bougainvillea* is unrivalled both in beauty and utility, particularly in the gardens of tropics and sub-tropics. A native of South America, *Bougainvillea* was discovered in 18th Century by the French botanist Commerson, at Rio de Janeiro, Brazil, who named it after Louis Antoine de Bougainville, the French navigator, with whom he went on a voyage round the world during 1766–1769. It was first introduced into Europe from its home in South America, during the 19th century and from Europe it moved subsequently into tropical Asia, Africa, Australia, New Zealand and other countries. According to Holttum (1970), the species *Bougainvillea spectabilis*, was the first to be introduced in Europe, in 1829. In India also, *B. spectabilis* was the first species to be introduced, coming from Europe in 1860. Later, two more species *B. glabra* and *B. peruviana* were reported to have been introduced into Europe and other countries. In India, two cultivars of *B. peruviana* were reported to be grown by the Agri-Horticultural Society, Madras, in 1935.

CROP IMPROVEMENT

Bougainvillea, belonging to the family Nyctaginaceae, has ten species (Heimerl, 1900), but only three species *B. spectabilis, B. glabra* and *B. peruviana* are of horticultural importance. Holttum (1970) in his comprehensive account of bougainvilleas has described four species. In addition to *B. spectabilis*, *B. glabra* and *B. peruviana*, he has described *B.* × *buttiana*, which he considered to be a natural hybrid between *B. peruviana* and *B. glabra*. It was first recorded at Trinidad in 1910, named 'Mrs Butt', after Mrs R.V. Butt, who first collected it from Colombia. However, Holttum (1970) recognised only three species and considered 'Mrs Butt' (*B.* × *buttiana*), a variety developed as an interspecific hybrid. He has listed several cultivars under another interspecific hybrid

'Spectoglabra' (*B. spectabilis* × *B. glabra*). Most of the garden cultivars of bougainvilleas have arisen by hybridization and mutation among the three basic species mentioned above.

Bougainvilleas are among the most floriferous shrubs of the tropics, producing beautiful colour effects which can hardly be excelled by any other plant. These are easy to grow, hardy often scandent shrubs. In the recent years these have become one of the most popular garden plants all over the world.

In India, the *Bougainvillea* improvement work started in the early 20th century, with the introduction of a few varieties by the Agri-Horticultural Societies at Calcutta and Madras. 'Scarlet Queen', named by Sir Percy Lancaster in 1920, is probably the first *Bougainvillea* raised in India. This was from the population of a variety similar to 'Mrs Butt', received from the West Indies. A large number of varieties have since been developed and released in our country, mainly by private nurserymen. The nurseries which have been credited with the release of varieties include K.S. Gopalaswamiengar Son, Bangalore, Soundarya Nursery, Madras; Chandra Nursery, Sikkim and Palekar & Co., Bombay. In addition to Sir Percy Lancaster, who has been the pioneer in the development of bougainvilleas in this country, others who have made significant contributions in this field include K.S. Gopalaswamiengar, P.S. Swaminathan, B.S. Nirody, B. Rama Rao, B.P. Pal, M.H. Marigowda. *Bougainvillea* improvement on scientific lines has however been done at a very few scientific institutions in our country in the last two decades or so. Dr B.P. Pal, the then Director of the IARI, New Delhi, initiated some work and developed 4 varieties in 1959. The NBRI (formerly National Botanic Gardens), Lucknow, also took up work on bougainvilleas around the same time, largely at the initiative of Sir Percy Lancaster. Later, some very good work was done at this Institute by T.N. Khoshoo and his associates and as a result a few really promising varieties have been developed.

As mentioned earlier, most of the garden cultivars of bougainvilleas have been developed from the 3 basal species *B. spectabilis*, *B. glabra* and *B. peruviana* and also from *B.* × *buttiana*. While the species and their cultivars can be distinguished by their growing habit, shape and size of the leaf, the surface of leaf, the colour, size and shape of bracts, the shape of flower tube and its surface, the size and shape of the hairs on the flower tube, the presence or absence of the star, its colour and size and the flowering habit, the nomenclature of cultivars has always been very confusing. Various workers have developed keys based on different characters for the identification of the cultivars. Bor and Raizada (1954), among the Indian workers, based their classification on the hairs on the plants, the tips of the bracts, and the colour of the bracts.

Swarup and Singh (1964) observed that pollen grains of different species

differed in the shape of apex of brochi besides showing difference in pollen size and number and size of brochi. Further, they also observed the length and density of the leaf hairs and the latter characteristic was found to be more helpful than the former in the identification of different species. Although they recorded the length and density of hairs on mid-rib, veins and lamina, the differences were found pronounced on the mid-rib. The tips of brochi were acute in *B.* × *buttiana*, round in *B. peruviana* and almost intermediate in *B. spectabilis*, whereas *B. glabra* was characterized by its prominent thick ring around the exine of the pollen grain. In *B.* × *buttiana*, the flower tube is constricted in the middle, but was sparsely hairy. It also had malformed flowers with no star and exserted stamens in some cultivars. Its bracts change their colour from light shades when young to dark shades when old, unlike the other species, in which it is the reverse. Besides, the tips of brochi of pollen grains were characteristically acute. All these characters lend support to the suggestion that *B.* × *buttiana* be considered a natural hybrid of *B. peruviana* with *B. glabra.* Nair (1965) also suggested pollen morphology to be a more stable character for the identification of species and cultivars. He reported difference in the size and number of brochi in pollen grains of different cultivars.

Although during the short period of its popularity, a wide array of hybrids and bud sports have appeared from the 3 elemental species (*B. glabra*, *B. peruviana* and *B. spectabilis*), much more remains to be achieved. Outside the humid tropics, progress in any comprehensive breeding programme is hampered by the extensive pollen and seed sterility. It is, therefore, essential that we have a complete knowledge of the genetic system of the crop. This kind of study, besides giving us a correct assessment of the extent and nature of the sterility, may help us in finding ways of its rectification by genetic means. Normally, sexual sterility resulting from genic, structural, segregational and environmental causes does not affect the survival potential of bougainvilleas, because of clonal multiplication. But, for effecting any genetic improvement, restoration of the fertility may become imperative (Zadoo and Khoshoo, 1968).

Ninan *et al.* (1958) studied the meiotic behaviour, pollen fertility, and pollen size in some *Bougainvillea* cultivars. They concluded that high pollen sterility in many varieties was due to irregular meiosis and particularly due to a high frequency of univalents. Non-functionability of stainable pollen and the sterility of ovules could be the reason for lack of seed setting. They opined that the *Bougainvillea* species with $2n=34$ may comprise two genomes with different time cycles of meiotic division. Zadoo and Khoshoo (1968) observed a case of interchange heterozygosity in a cultivar of *B. peruviana,* in which there was regular formation of 15 bivalents

and an interchange multiple of 4 chromosomes. The multiple was always associated with the nucleolus at diakinesis, indicating that one of the chromosomes involved was nucleolar. The nucleolar pair of chromosomes were slightly heteromorphic which may be due to an unequal interchange. Although 80% of interchange multiples orientate non-disjunctionally, yet 65% pollen was stainable. The pollen was ineffective in self-pollination but highly effective in crosses with 2x and 3x cultivars of *B. spectabilis.* The higher pollen stainability indicated that the deficiencies and duplications caused by non-disjunction do not have serious physiological effects on pollen grains and that its genome can withstand rearrangements.

Khoshoo and Zadoo (1969) in their study of 60 cultivars of *Bougainvillea* found 58 to be diploid (2n=34) and 2 ('Perfection' and 'Poultonii Special') triploid (2n=51). While 10 cultivars had pollen stainability ranging from 50 to 90%, with 7 having 50 to 80% ovule fertility, all the cultivars were self-sterile. This imposed considerable restrictions in the choice of parents by excluding cultivars that may be sterile, but otherwise may possess useful characters. To have a broad-based germplasm, they felt some method should be evolved for restoring pollen or seed fertility or both. They induced tetraploidy (2n=68) in three totally male and female sterile cultivars. Extensive intercrossing programme involving these induced tetraploid with diploid and triploid parents resulted in 40–100 % seed set. Although fully fertile pollen, all the induced-tetraploid cultivars nevertheless remained self sterile indicating thereby a sporophytic control of incompatibility associated with trinucleate pollen and simultaneous cytokinesis. It was apparent from the breeding behaviour of induced tetraploids that they not only have nearly normal male fertility, but, also a high degree of female fertility. This indicates that total sterility in diploids was a result of recombination between homologous chromosomes or segregational hybrid sterlity. In addition to identifying the nature of sterility, which is a serious obstacle in *Bougainvillea* breeders, and establishing a method for overcoming its genetic deficiencies; these results permitted incorporation of a good deal of germplasm into the breeding programme previously out of reach of the *Bougainvillea* breeders.

The work of Khoshoo and Zadoo in the 1969 gave us new perspectives in Bougainvillea breeding. Khoshoo and his co-workers were able to develop several new varieties with this new technique. But if one looks at the gamut of new cultivars developed all over the world, it is evident that most of the cultivars have arisen as a natural bud sport or mutation. This aspect, indicated the possibilities of inducing mutations to obtain new cultivars. Gupta and his co-workers initiated the work on artificial induction of mutations at the NBRI, Lucknow. They observed that effects of different doses of gamma-rays on cuttings of bougainvilleas varied with the cultivars. This indicated that the bougainvilleas were very sensitive to radiation. Abraham and Desai (1977) also reported

bougainvilleas in general to be sensitive to low doses of radiations and observed that with acute doses of X-rays and gamma-rays, it could not withstand doses beyond 2 Kr administered to fresh cuttings. With chronic gamma-ray doses, there was no survival beyond 5 Kr. It was therefore found suitable to administer recurring low doses of radiations to increase surviving populations and to induce mutations.

At the NBRI, Lucknow, with variety 'Partha' in a plant irradiated with 250 rads of gamma-rays, a mutant with variegated leaves was isolated. This branch multiplied by layering gave the new variety 'Arjuna' (Gupta, 1979). Abraham and Desai (1977) also observed, the cultivar 'Jayalakshmi' on exposure to gamma-radiation developed a branch with variegated leaves. They isolated this mutant and multiplied it by vegetative means. This mutant was less vigorous in growth and was late-flowering compared to control, probably because of the reduced chlorophyll content in leaves. Some of the other mutants developed by them are 'Jaya', 'Lady Hudson of Ceylone Variegata' and 'Silver Top'.

It must be mentioned that in addition to the work done at the NBRI, Lucknow, the IIHR, Bangalore, also took up systematic work on *Bougainvillea* breeding. They have carried out planned research programme on the improvement of this crop. By rigorous selection, much improvement has been carried out in this crop. Thereafter, 6 promising cultivars have been developed and released.

PROPAGATION

Besides, the crop improvement in bougainvillea the other aspect which has attracted lot of interest among the research workers has been propagation. The *Bougainvillea* is propagated by cuttings, layerings, *gooties* (air-layering) and budding. *Bougainvillea* can also be grown from seeds for obtaining new varieties. However, all varieties do not produce seeds. On the contrary, 'Formosa' and 'Trinidad' set seeds profusely. The climate also affects the seed-set. In India, seed-setting is better in Bangalore than in Delhi. The method to be employed for propagation would largely depend on the variety. While a large number of varieties could be easily multiplied by cuttings, there are also varieties like 'Thimma' and 'Bois-de-Rose', which are difficult to root and one has to resort to budding or layering for their multiplication.

Misra (1971) observed varietal differences in their response to seradix treatment in rooting and survival. They reported profuse rooting and maximum survival in 'Blondie', 'Elizabeth', 'Pixi', 'Rosa Catalina' and 'Sundari'. Mishra and Singh (1984) observed that varietal differences and weather conditions affected rooting in *Bougainvillea* cuttings. They also observed that varieties of *B. glabra* and *B.* × *buttiana* rooted better than those of *B. spectabilis* and *B.*

peruviana. In 'Mahara', Yadav *et al.* (1978) observed that cuttings planted in the middle of August performed better in terms of percentage of cuttings rooted, average root number per cutting, and average root length. Several research workers used growth regulators to induce rooting of cuttings. Singh and Rathore (1977) used softwood, semi-hardwood and hardwood cuttings treated with IBA at 1000 ppm and planted in the open sunlight and partial shaded polythene tents. While all the softwood cuttings rooted, their survival percentage was low compared with the hardwood cuttings. No cutting planted in the open sunlight rooted, whereas 91% rooted when planted in shade. Bhattacharjee and Balakrishna (1983) observed that 15–20 cm long cuttings with 3–5 leaves treated with 4000 ppm NAA or 4000 and 6000 ppm IBA gave 80% rooting and 100% survival. Apical cuttings had better rooting and survival percentage as compared to basal or middle cuttings. However, the rooting percentage of cuttings treated with 4000 ppm IBA was highest in sand followed by vermiculite.

Gandotra *et al.* (1975), Philip and Gopalakrishnan (1981, 1982) and Bhattacharjee and Balakrishnan (1983) also observed significantly better rooting with IBA 6000 ppm (4000 ppm, Bhattacharjee and Balakrishnan, 1983). Shield buds prepared from dethorned shoots, when the thorns were young and tender, gave better budding success (Nair, 1972). February was the best month for rooting and survival of cuttings propagated under intermittent mist (Singh and Motial, 1979). IBA 3000 ppm was more effective than NAA. Singh *et al.* (1976) were able to induce rooting in difficult-to-root 'Mary Palmer' and 'Bois-de-Rose', by growing them under bottom heat after treating them with 5000 ppm IBA.

Plant regeneration from cultures of meristem and tissue has special significance in *Bougainvillea* because of the fair incidence of bud sports in this plant (Zadoo *et al.*, 1975) and new cultivars can be created in a short time by isolating the mutated tissue and organ and regenerating the whole plants from it. Chaturvedi (1979) reported fast proliferation of shoot apices of *B. glabra* 'Magnifica' in a combination of BAP and IAA. The isolated shoots were rooted resulting in the formation of complete plants which were successfully grown in soil. Several shoots were repeatedly obtained from a single culture effecting rapid clonal propagation. These *in vitro*-raised plants produced true-to-type flower under field conditions. Even in case of 'Scarlet Queen Variegated', a difficult-to-root cultivar, nearly 100% rooting of shoots was obtained *in vitro* (Chaturvedi, 1979).

BASIC STUDIES

A few basic studies have also been attempted on the use of growth regulators and other chemicals with *Bougainvillea.* Hove and Bose (1970) observed

growth retardation with Cycocel B-9 and Phosfon on 5 *Bougainvillea* cultivars. Maximum growth retardation was recorded with 8000 ppm Cycocel. Application of 4000 ppm Cycocel increased the number of flowers and bracts. Rao and Mallikarjuna (1978) observed that when leaf discs of *B. spectabilis* were soaked in 10 ppm pantothenic acid, the rate of chlorophyll breakdown had decreased. Misra and Pradhan (1982) also floated leaves of *B. spectabilis* on solutions containing sodium chloride, calcium chloride, gibberellic acid, kinetin and benzimidazole at various concentrations and found that benzimidazole at 10^{-5} M advanced senescence by 5 days. Kochhar and Ohri (1977) and Kochhar *et al.* (1979) conducted biochemical analysis of the bracts of bougainvilleas and resolved the pigments constituting the magenta colour. Ohri and Khoshoo (1982) studied the DNA content of the three basal *Bougainvillea* species.

Flowering was induced in the *in vitro*-grown shoot apices of *B. glabra* and *B.* × *buttiana*, taken from non-induced plants, under non-inductive photoperiods. The flowers were normal and had the mother-type bract colour. These results have both fundamental and applied significance that besides helping in enumerating the biochemical nature of the so-called 'florigens', which is not yet known, they may also help in speeding up the selection process of desirable new cultivars (Chaturvedi, 1979).

Bougainvillea has been used as the material for several other studies conducted at different laboratories in India and some useful results of basic nature obtained. Some of these could form the basis for further experimentation and could be used in future planning of *Bougainvillea* research in India.

CULTURAL ASPECTS

From the preceding account, it is evident that *Bougainvillea* has received the attentions of research workers in India mainly for crop improvement and some work on propagation has also been attempted. The cultural aspects have not been touched at all. The main reason for this is that no problems of serious nature in *Bougainvillea* culture have been reported. It is a very easy-to-grow plant and hardly needs any special care. A bit of watering initially for establishment and natural sunshine are all the inputs required for its successful growing. It grows in any kind of soil and in fact thrives well in drier regions and on rocky terrain. As mentioned earlier, it is one of the very versatile plants and could be put to various uses in the garden. It could be grown as a pot plant, as a bush specimen, an impenetrable hedge, a standard, a ground cover, or trained up a tree. The improvement work done in India has yielded a large number of improved varieties suited for different purposes. Out of

more than 150 cultivars developed in our country, some of the popular and promising are 'Begum Sikander', 'Chitra', 'Dr H.B. Singh', 'Dr R.R. Pal', 'Enid Lancaster', 'Happiness', 'Jawahar Lal Nehru', 'Jayalakshmi', 'Krumbiegal', 'Lalbagh', 'Lord Willingdon', 'Louise Wathen', 'Maharaja of Mysore', 'Mahatma Gandhi', 'Manohar Chandra', 'Mary Palmer', 'Mary Palmer Special', 'Meera', 'Munivenkatappa', 'Partha', 'Princess Margaret Rose', 'Purple Gem', 'Purple Queen', 'Rao', 'Rosea Fuchsea', 'Sensation', 'Shubhra', 'Sonnet', 'Spring Festival', 'Srinivasa', 'Stanza', 'Summer Time', 'Thimma', 'Vellayani' and 'Zakeriana'.

As mentioned in the earlier part of this paper, it is recognised that the work on development aspect in this crop has largely been done by the Agri-Horticultural Societies at Calcutta and Madras. The Lal Bagh Garden at Bangalore also contributed a great deal by introducing a large number of exotic cultivars, particularly the multibracted varieties from the Philippines.

BOUGAINVILLEA PROMOTION

The IARI, New Delhi, was designated as the International Registration Authority for Bougainvillea Cultivars by the International Society for Horticultural Science, and it has compiled a check-list of more than 300 varieties developed all over the world. This check-list is a very useful document for reference purposes, giving authentic descriptions of the varieties. In 1973, the Bougainvillea Society of India was formed with the main objective of inculcating among people a love for this colourful plant. The Society through the organization of an annual Bougainvillea Festival at Delhi has also done a yeoman service by bringing to the notice of the public the large wealth of varieties available in this plant.

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9

Jasmine

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JASMINE blossoms have been in use in India for ceremonial purposes since time immemorial. The word *Jasminum* has been derived from the Persian word 'Jas-Minum' meaning fragrance. The genus *Jasminum* belongs to the olive family Oleaceae. It consists of about 90 species distributed over Asia, Africa, Australia and Southern Europe. About 40 species are reported to occur in India

The distribution pattern of as many as 72 of these in India, Malaysia and China provides a strong basis to claim that Indià may be one of the principal centres of origin of *Jasminum* species. The reference to the three cultivated species, viz. *J. auriculatum, J. grandiflorum* and *J. sambac*, in ancient Tamil literature belonging to the Sangam Era prior to 500 B.C. suggests that South India may possibly be the home of alteast some of these species.

IMPORTANCE AND USES

Jasmine is one of the oldest of fragrant flowers to be cultivated by man. In India, the jasmine flowers and buds are used for preparing garlands, bouquets and *veni* for religious offerings. In South India, large quantities of jasmine flowers are used by women folk for adorning their hair. The flowers are also used for the production of perfumed hair oils and *attars* particularly in Uttar Pradesh. The world famous 'jasmine oil' is extracted from the flowers of the Spanish jasmine (*J. grandiflorum*). The jasmine oil is regarded as unique as it blends well with floral extracts and it is highly valued throughout the world for producing high-grade perfumes. The oil finds use in soap and cosmetic industries also.

In India, jasmine is cultivated throughout the country. Although correct statistics of the area and production are not available, it is estimated that it occupies an area of about 8,000 ha with an annual production of flowers worth Rs 80–100 million. The country exports jasmine flowers

to the neighbouring countries like Sri Lanka, Singapore, Malaysia and of late to the Gulf countries. Although India has been cultivating jasmine for the past several centuries, it does not currently figure in the jasmine perfume trade of the world. In recent times, there is a growing market for spirituous perfumes and colognes particularly in countries like Japan, the UK, the USA, the USSR, Scandinavia, East Europe, etc. India lost its leading position as a perfume country because of its countinued reliance on *attars* and non-spirituous perfumes of the traditional type. It is thus obvious that there is a good scope for large-scale development of spirituous perfumes based on jasmines for export purposes.

SPECIES OF JASMINUM

J. auriculatum, J. grandiflorum and *J. sambac* are the three commercially important *Jasminum* spp. of India.

In case of *J. auriculatum* Vahl. (*Juhi, mugohee, sunika, oosi mallige, pindari, kadaru mallige*) flowers are white, sweet-scented, and are used for production of perfumed oil and *attar.*

J. grandiflorum L. [Syn. *J. officinale f. grandiflorum*] (common jasmine or Spanish jasmine, *chameli, jathimalli, safed chambeli*) bears flowers which are white often tinged with purple on the outside; delightfully fragrant and are used in making garlands, decorative bunches and *veni.* Small quantity is used for preparation of hair oil and *attar.* Presently jasmine concrete is extracted from the flowers of this species only. This species is cultivated in Tamil Nadu and Uttar Pradesh.

In *J. sambac* (L) Ait. (Arabian jasmine or Tuscan jasmine; *moghra, champa, motia, malli, mogri, adukkumalligai* and *gundumalligai*) flower buds are white, with single or multiwhorled petals; widely used in making garlands, bouquets, in religious offerings, extraction of perfume (otto) and in cosmetic industry.

In *J. arborescens* L. (*muta bela, naba malliga*), flowers are white, very fragrant. This is grown in West Bengal and Uttar Pradesh.

J. calophyllum Vahl. (*pandal malli*) is a profuse-flowering species generally grown in home garden with staking flowers which are scented, white, produced practically round the year and are free from pest-and-disease attack.

J. flexile Vahl. [Syn. *J. caudatum* Wall.] (*malati, nitya mallige*) is a profuse-flowering species grown widely in home compounds for its scented flowers. It bears flowers practically throughout the year and is free from insect pests.

J. humile L. [Syn. *J. bignoniaceum*] (Yellow jasmine, *semmalligai, pellichambeli*) bears flowers which are yellow, fragrant, and are used in perfumery.

J. pubescens Willd. [Syn. *J. multiflorum* Burm. f.] *(kunda, kundo).* Its plants are very ornamental, flowers are slightly fragrant and white and flower throughout the year with a peak in winter. This is popularly grown in north India since its performance is better in cool climate.

VARIETAL SITUATION

Research efforts to catalogue the existing variability in jasmines for evolving superior forms for fresh flower use and for essential oil extraction were made by the Tamil Nadu Agricultural University. Raman (1955) attempted a classificat on of existing varieties under *J. sambac* primarily based on number of whorls of corolla and leaf characters. Fifteen distinct morphological variants showing differences in floral characters like length of pedicel, corolla tube length, and shape of flower bud were identified. Of these, cultivars 'Madanban', 'Gundumalli' and 'Ramabanam' were adjudged superior in y eld. In *J. auriculatum* five morophological variants differing chiefly in the flower bud characters were identified and named as 'Long Point', 'Long Round', 'Medium Point', 'Short Point' and 'Short Round'. These clones exhibited differences in their degree of susceptibility to the common gall-mite pest and one clone, viz. 'Medium Point', was found to be highly resistant to this pest. Besides the above characters, these clones showed variations in diameter of open flower, weight of flower bud, corolla tube length, fruit-set and heterostyly. Such variants might have arisen as a result of chance hybridization in nature or occurrence of bud sports as controlled crossings resulted in failure. According to Chandra (1982) the varieties 'Palampur', 'Madanban', 'Mogra' and 'Motia' are double-flowered.

In *J. grandiflorum* six distinct variants differing in floral characters and ploidy level were catalogued. Of these five have pink-tinged buds while the sixth is whitish. One of the 'pinks' proved to be triploid (2n = 39) (Fig. 1) and the rest diploids (2n = 26) (Fig. 2). The triploid was found to be exceedingly sterile.

CROP IMPROVEMENT

Introduction, clonal selection, half-sib evaluation, hybridization, mutagenesis and ploidy breeding were attempted for identifying or evolving superior forms in respect of flower bud characters, yield, quality of fresh flower and essential oil content in the commercial jasmines.

Introduction and clonal selection. The pioneering work carried out by the Tamil Nadu Agricultural University showed that in *J. grandiflorum*,

Fig. 1. *Jasminum grandiflorum* (triploid).

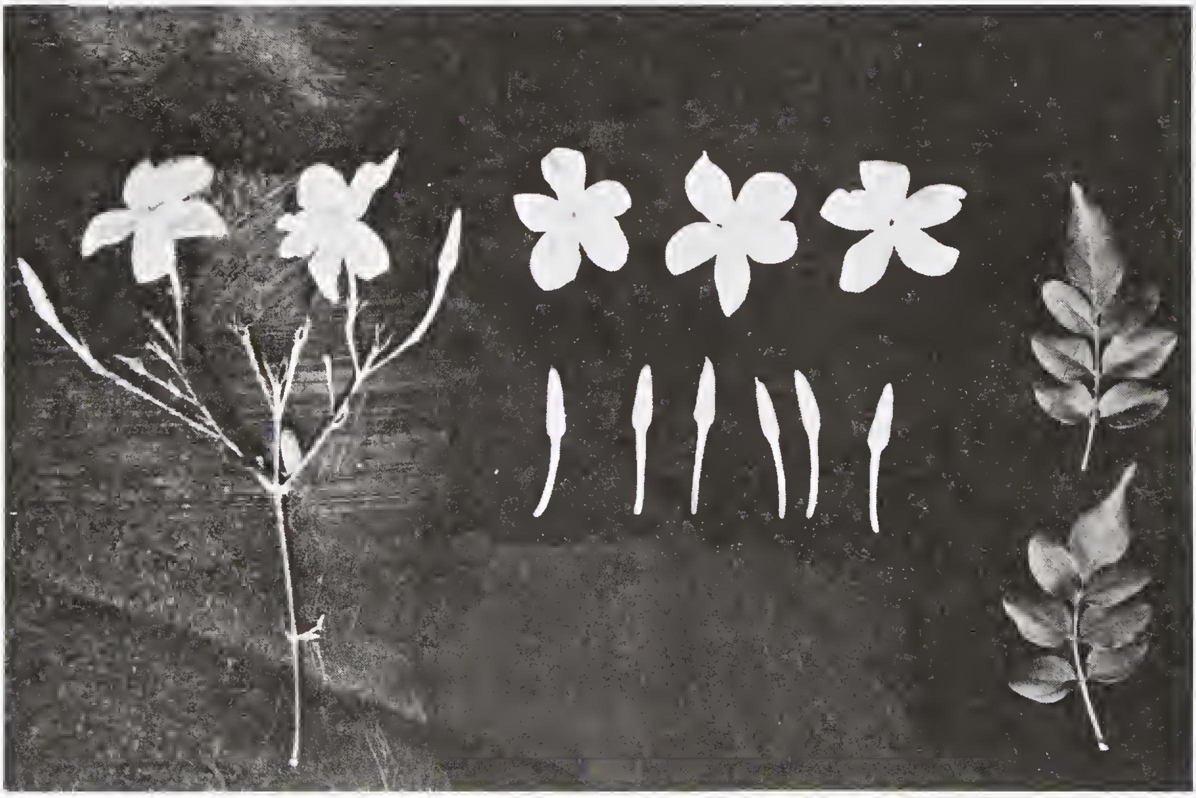


Fig. 2. *Jasminum grandiflorum* (diploid).

the clones from different states in the country showed considerable variations in respect of flower production as well as yield of jasmine concrete. The mean flower bud yield of the six clones varied from 4,329 kg/ha to 10,144 kg/ha while that of jasmine concrete showed a range of 13.85 kg/ha to 29.42 kg/ha (Veluswamy, 1980). This led to the release of an improved variety named 'Co 1 Pitchi' (*J. grandiflorum*) with an yield of 10.15 t/ha of flower buds with a concrete recovery of 29.5 kg/ha. The colour of flower bud is pink and attractive with pleasant fragrance suitable both for fresh flower trade and oil extraction. Similar work carried out in *J. auriculatum* led to the identification of a high-yielding gall mite-resistant clone 'Parimullai', which was released by the TNAU in 1971 for cultivation by growers. The clone is characterised by a long flowering season of nine months and a mean flower bud yield of 10 t/ha (Madhava Rao and Muthuswami, 1972). The selection nevertheless suffers from undesirable corolla tube length. Later a secondary selection, viz. 'Long Round', was found more prolific in yield and possessed larger corolla tube as well as bud length and this was released as 'Co 1 Mullai'. This is capable of yielding 8,800 kg/ha with good consumers' perference. Valuswamy (1981) found clones of *J. grandiflorum* superior to *J. auriculatum* in flower bud yield, though in jasmine concrete recovery *J. auriculatum* was better with 344 mg/100 g as against 288 mg/100 g in the former.

Hybridization. Interspecific hybridization involving *J. auriculatum, J. grandiflorum, J. flexile, J. calophyllum* and *J. sambac* attempted in the past have shown that the success was very low ranging from 0.5 to 5%. The seeds of direct as well as reciprocal crosses failed to germinate. However, a success of 3–16% was recorded when an induced tetraploid of *J. auriculatum* was used as female and *J. grandiflorum, J. angustifolium, J. flexile* and *J. calophyllum* as donors. But the seeds of these crosses also failed to germinate. With the same female parent, crosses using *J. rigidum, J. arborescens* and *J. paniculatum* as male parents also ended in failure. Interspecific hybridization among the wild species also met the same fate. Veluswamy (1981) reported successful fruit set in the combinations involving *J. auriculatum* with *J. flexile* and *J. grandiflorum*; *J. grandiflorum* with *J. auriculatum, J. calophyllum* and *J. flexile*; and *J. sambac* with *J. grandiflorum.* But in all these cases, the seeds failed to germinate showing a strong barrier for crossability and hybrid inviability existing among the different species and also the possibility of endosperm antagonism in operation. Existence of pollen sterility and seed sterility due to defective egg mechanism have also been indicated. The sterility factors operating in jasmines have been reported by Mridula Dutt (1952) and Murthy and Khanna (1971).

Intraspecific hybridization on the other hand showed partial success ranging from 0.5 to 35% in *J. grandiflorum.* The crossed seeds registered a germination of 50–100%. Cross incompatibility was also evident in some of the interclonal

crosses. This indicates the genetic divergence of the clones in different degrees and the possibility of exploitation of such divergence for improving the economic attributes. In addition, reciprocal differences also seem to exist thereby indicating the operation of one way incompatibility system.

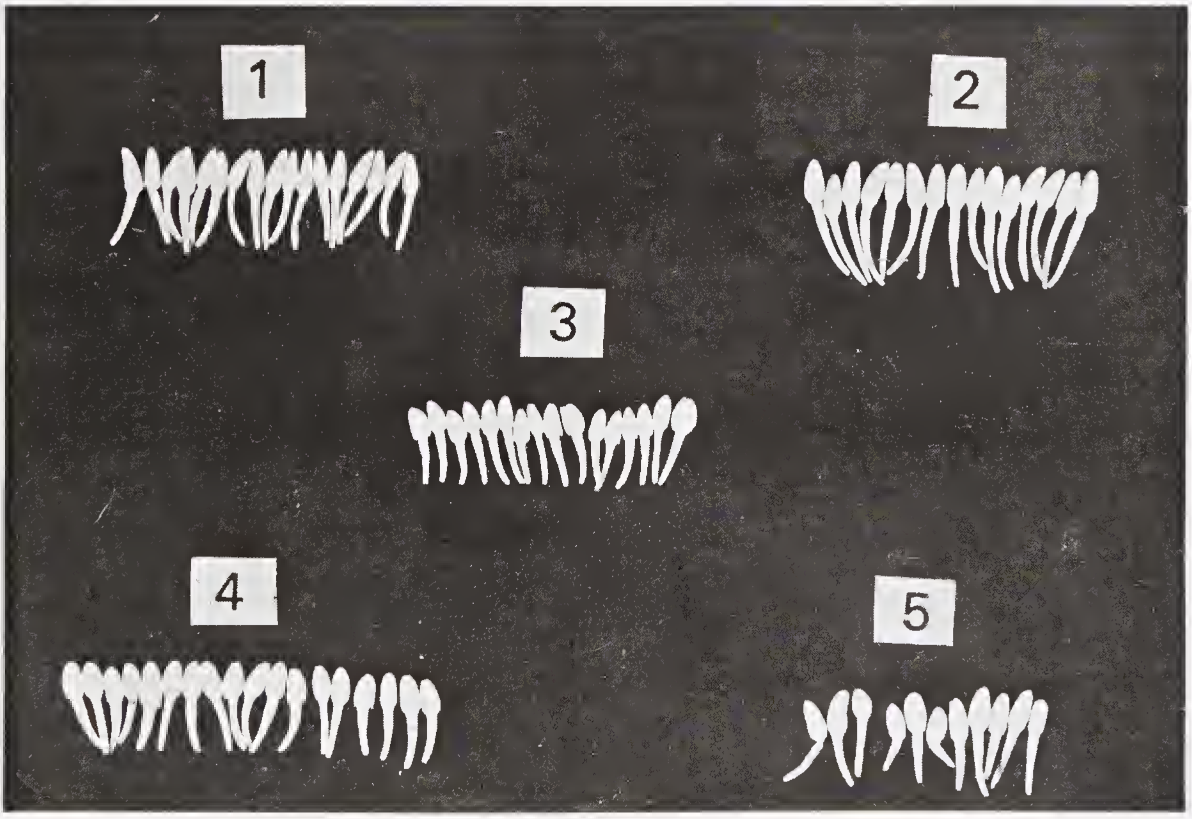
In *J. auriculatum*, success was obtained in 'Short Round' × 'Short Point', 'Parimullai' × 'Short Point' and an induced tetraploid × diploid of *J. auriculatum*. Fruit set on crossing ranged from 0 to 27%. However, none of the progenies proved economical (Fig. 3).

Ploidy breeding. Jasmines are generally diploids with 2n = 26. However, natural occurrence of forms with higher ploidy levels have also been reported (Alikhan *et al.*, 1969; Murthy and Khanna, 1971) as given below:

J. sambac var. 'Gundumalli'	2n=39
J. flexile (Cultivated variety)	2n=52
J. primulinum	2n=39
J. angustifolium	2n=52

In general, triploids have been found to be more vigorous and better yielders than diploids while tetraploids are robust, hardy and produce bolder flowers.

Fig. 3. Flower bud character in *J. auriculatum*.



Artificial induction of polyploids has been found feasible in *J. auriculatum* but not in *J. grandiflorum* (Veluswamy, 1981). Seed or seedling treatment with 1% colchicine recorded 11.4–23.1% in *J. auriculatum.*

Induction of polyploids was attempted in the diploid forms of *J. auriculatum* and *J. grandiflorum.* Seeds of 'Short Point' clone of *J. auriculatum* were treated with 0.5% colchicine for 12 hours and 24 hours. One tetraploid seedling was obtained from 'Parimullai' (*J. auriculatum*) seeds. In general, tetraploids were found to be poor yielders with low concrete recovery. Treatment of vegetative buds with 0.1 to 0.5% of colchicine did not yield any useful polyploid. In *J. grandiflorum* 0.5% colchicine seed treatment resulted in six tetraploids which were however not found to be economically useful. In J. *sambac* tetraploids were found more vigorous but produced less number of bold flowers per plant (Alikhan *et al.*, 1969). The natural triploids are found to be vigorous with higher yields than diploids.

Mutagenesis. Both chemical and physical mutagens have been tried in *J. auriculatum.* X-ray treatment of active vegetative buds produced no mutagenic effect. Seed treatment with gamma-rays beyond 10 Kr proved lethal. A mutant with longer corolla tube was spotted but it was found to be susceptible to gall mite. Use of chemical mutagens showed that soaking in EMS at 0.1% for 72 hours proved lethal. However, with the use of this chemical, one mutant was secured which had undesirable traits. In *J. grandiflorum* gamma-rays of dose beyond 30 Kr proved lethal. Although 10 mutants were isolated with lower dosages, none proved to be good for flower yield. Treatment of soft-wood cuttings with gamma-rays (1 to 10 Kr) also met the same fate suggesting the limited role of mutagenesis in jasmine improvement.

PROPAGATION

Layering had been the mode of vegetative propagation in Jasmines until recently. Simple layering during June-July to October-November gives good success in 90–120 days. After rooting, the plants are separated and kept in shade covering the roots with a wet gunny until required for planting.

Propagation by rooting of cuttings has been attempted and perfected in *J. auriculatum* and *J. grandiflorum.* Singh and Bhatnagar (1955) studied the effect of IAA and NAA on rooting of soft- and hardwood cuttings of *J. grandiflorum.* The highest rooting of 90% was recorded in soft-wood cuttings treated with IAA 1,000 ppm and in hardwood cuttings treated with 500 ppm. Bose *et al.* (1973) also confirmed the effectiveness of IAA and NAA in rooting of cuttings of this species. Sand medium and cuttings taken in May contributed to higher success (Anon., 1977), thereby showing the influence of

the kind of rooting medium and season of propagation on the final success achieved in rooting. Terminal five nodal cuttings in *J. grandiflorum*, terminal and semi-hardwood cuttings in *J. sambac* and *J. auriculatum* were found best suited for propagation in mist chambers. Among other species, *J. calophyllum* and *J. rigidum* rooted easily while *J. humile* recorded low success (Anon., 1974).

Studies on grafting jasmines were carried out by Veluswamy *et al.* (1980). There was a perfect union of scion and rootstock in the case of *J. grandiflorum* on *J. auriculatum, J. communis* and *J. sambac*. The scion grew for about six months and flowered, but the flowers did not show any variation.

CULTIVATION

Spacing and planting. Spacing is one of the factors which determines the ultimate flower production. In commercial cultivation it varies from place to place and also depends upon the species cultivated and the soil conditions. The famous Spanish jasmine is planted at a closer spacing of 80 cm × 10 cm with 100,000 to 150,000 plants per hectare. Studies carried out at Tamil Nadu Agricultural University, Coimbatore, have shown that among the various spacings tested for *J. grandiflorum* the closer spacing of 2 m × 1.5 m with a population of 3,333 plants per hectare recorded the highest yield.

For planting, pits of 45–90 cm^3 are prepared depending on the type of soil and are exposed for a week. Afterwards, half the pit is filled with dried leaves and burnt to kill the disease organisms present in the soil. A day later, the lower half of the pit is filled with top-soil. The upper half of the pit is filled with the top-soil after mixing with 10 to 20 kg of well-rotted cattle manure or compost to a level of 10 cm above the ground level. Then a soaking irrigation is given to the pits for soil to settle down. A mixture of 5% BHC and 5% DDT at 3 to 5 g per pit may be added to the top 30 cm of the soil in the pit to prevent white ant attack. Planting can be done after a day.

Nutrition. Systematic investigations to determine the nutrient needs of the crop have been attempted only since the last one decade. At the Tamil Nadu Agricultural University, Coimbatore, several experiments on the subject have been carried out. In *J. auriculatum*, N at 120 g per plant recorded the highest yield. P and K at 240 g each per plant individually did not influence the yield. But under 120 g N, the plants registered better yields when applied along with P and K at 240 g each per plant. Hence, a balanced fertilization was considered beneficial. Muthuswami and Pappiah (1976) observed that the level of N can be reduced to half (60 g/plant/year) if applied as foliar sprays at monthly intervals.

In *J. grandiflorum* soil application proved to be better than foliar application. Foliar application at all levels depressed the yields. Application of N P K at 60:120:120 g per plant along with 10 kg of farmyard manure applied in two splits,

once in January and again in July every year, was found optimum. Subsequent studies to determine the effect of graded doses of N (0,30,60 and 120 g/plant) and P (0,60,120 and 240 g/plant) under a constant K dose of 240 g and farmyard manure of 30 kg/plant showed that $N_{30}P_{120}$ and K_{240} g per plant constituted the most economic dose for this species.

At Kalyani, West Bengal, the recommended fertilizer dose for maximum growth and flower production is $N_{50}P_{15}K_{15}$ for *J. auriculatum* and *J. sambac* (Anon., 1978). The results of study by Natarajan *et al.* (1981) revealed that application of N,P and K each at 240 g per plant per year at bimonthly intervals is optimum under Madurai (Tamil Nadu) conditions.

Pruning. Pruning is an important tool for manipulation of flowering as it influences flower bud initiation, differentiation and ultimately the flower production. Normally irrigation is withheld prior to pruning and plants are pruned by removing all the past season shoots including dead and diseased branches to a height of about 45 cm from the ground level. All the leaves in the bushes are stripped off. Following pruning all cut ends are smeared with Bordeaux paste to prevent infection. Muthuswami *et al.* (1973) observed that pruning during the last week of January led to the maximum flower production in *J. auriculatum* and pruning beyond this date resulted in lower yields. According to Pal *et al.* (1980) for the variety 'Single', December and January pruning proved most favourable, the variety 'Double' responded best when pruned in February and the optimum height of pruning was arrived at 30 cm.

In *J. grandiflorum*, Muthuswami (1975) reported that the time of pruning influenced the quantum of flower yield in each month from February to October. Pruning as early as November did not help in shifting the peak flower production in June-July. Subramanian (1977) in his study showed that early pruning in December enhanced the duration of flowering up to eight months while it was five months in the late-pruned crop. The highest yield was obtained in plants pruned on 28 December and the lowest yield from plants pruned on 28 March.

The effect of pinching of new shoots to stagger the flowering and thereby spread the period of productivity was investigated by Muthuswami and Madhava Rao (1980). They found out that pinching delays flowering by 17.4 days in *J. grandiflorum* and 14.3 days in *J. auriculatum.*

Muthuswami *et al.* (1973) reporting on the effect of pruning in *J. sambac* var. 'Single Mohra' showed that flowering reached peak during March to May and declined thereafter with no flowering between October to January. Pal *et al.* (1980) under Kalyani conditions observed that though pruning did not produce any appreciable differences in branch number, pruning to a height of 20 cm as against 40 cm resulted in reduced branch number in *J. sambac* var. 'Khoya'. The plants pruned at 40 cm height in January

produced the highest yield. The usefulness of chemical defoliants for substituting manual purning was investigated (Muthuswami *et al.*, 1974). Chemical defoliants like paraquatdichloride, pentachlorophenol, potassium chloride and sodium chloride were employed in *J. auriculatum.* While paraquatdichloride caused quickest and heaviest defoliation, pentachlorophenol and sodium chloride produced increased yield over the unpruned plants. Use of defoliants as an alternate to manual pruning was thus effective.

In *J. auriculatum* spraying Ethrel at 1,000 ppm recorded greatest growth retardation, CCC at 1,000 ppm induced early flowering while B-nine produced greater number of laterals which produced flower clusters (Muthuswami, 1975). In *J. grandiflorum* CCC sprays at 500 ppm produced several effects such as early flowering, high yield, high essential oil content, better flower size and longer duration of flowering (Pappiah and Muthuswami, 1977). Good defoliation was noted with sprays of Ethrel at 2,000 ppm in *J. sambac* var. 'Gundumalli' while it failed in *J. grandiflorum.* Pal *et al.* (1980) reported that treatment with Ethrel promoted height of plants while CCC retarded growth in *J. auriculatum.* NAA application in general also resulted in reduced plant growth. Application of Ethrel 0.125 and 0.250 ml per litre and NAA at 25 mg per litre on *J. sambac* promoted more laterals resulting in increased flower number (in *J. sambac*, the above concentrations of Ethrel and NAA and CCC at 1.09 and 2.18 ml per litre increased flower number).

Regulation of flowering. The peak flower production in different jasmines varies with species and is generally confined to a few months in a year. It was found that pruning time in *J. auriculatum, J. grandiflorum* and *J. sambac* did not influence the peak season of flowering. Since jasmines are photo-insensitive, the role of other climatic factors, viz. temperature and rainfall on flowering, was studied. Muthuswami (1975) in his study on *J. auriculatum* found that temperature played a major role in the production of flowers. Early-pruned plantings (28 January) recorded high yield and longer duration of flowering as they received optimum heat units. These findings were confirmed in *J. grandiflorum* in which maximum flowering occurred in plants pruned in the later part of December.

The requirement of heat units decreased as the pruning was delayed. Raman (1973) observed a direct correlation between yield and mean temperature and no relationship with rainfall or humidity in *J. sambac.* The optimum time for pruning for *J. sambac* was fixed as the last week of November. The relationship between temperature and flowering in jasmines and the variation that exists among the different species in their specific requirement of heat units have been brought out by the above investigations. Further studies to ascertain the possibilities of shifting the flowering pattern were undertaken by pruning on different dates from early November to late

March at ten days intervals. Irrespective of the date of pruning, production during the months of June and July contributed the largest share to the total flower yield in *J. auriculatum.*

Similarly in *J. grandiflorum*, the peak flower production occurred between July and October under all pruning dates. Neither very early pruning in November nor late pruning in March disturbed this trend. Day length degree values are seen to have a relationship to the peak productivity in particular months. In both the species, the monthly output of flowers showed a negative association with relative temperature disparity (RTD). Lower difference between day and night temperature and relatively lower day temperature favoured a higher flower output. Thus diurnal temperature periodicity appears to have favoured more flower formation in particular months. According to Muthuswami and Madhava Rao (1980) the above two species can be regarded as responsive to thermo-periodism quantitatively and classified them as day-neutral plants requiring temperature alteration for flowering.

Off-Season Flowering. Induction of off-season flowering in *J. grandiflorum* cv 'Thimmapuram' was attempted (Vedamuthu, 1981). Spraying of growth regulants coupled with pruning round the year at monthly intervals revealed that pruning in January and spraying with Alar 1,000 ppm shifted the peak flowering to October. A shift in flower production to November was observed by pruning in February and spraying with CCC 500 ppm. Pruning from January to March in combination with Alar 1,000 ppm spray could prove helpful in extending the flower production in the off-season.

Yield. In *J. sambac* cv 'Gundumalli' and 'Iruvatchi', there was a steep rise in yield from February to April and gradual decline thereafter. In other cultivars the peak yield was in May or June. Although the commencement of flowering was at the same time, the quantum of yield and duration of flowering differed widely. This was attributed to photo-thermal influence. In low-yielding cultivars, higher day length and night temperatures were associated with poor yields. In the high-yielding cultivars, the highest yields were noted under a regime of high day length and day and night temperatures. These displayed their ability to produce more flowers per photo-thermal unit (PTU) than low yielders. Thus, the efficiency of different cultivars to produce flowers per PTU varied and depended on the interplay of both day length and temperature (Raman, 1973).

JASMINE OIL AND CONCRETE

Jasmine flowers owe their fragrance to a volatile oil present in the epidermal cells of the inner and the outer surface of both petals and sepals. The fragrance begins to develop in the flowers soon after sun-

set and ceases within a few hours of sunshine. Though jasmine flowers have been used in our country from time immemorial, commercial exploitation of these flowers for extraction of the fragrant oil is only of recent origin.

There is hardly any high-class floral perfume of oriental origin which does not contain at least a small percentage of jasmine flower oil. It gives smoothness and elegance to the perfume combinations. Several types of jasmine oil and perfume extracts from flowers such as concrete, absolute and pomade are available in the market.

Jasmine oil is at present produced in the Grasse Region of Southern France and to some extent in Italy, the UAR, Morocco, Tunisia, Turkey, Algeria, Belgium and Holland. The world production of jasmine concrete is said to be around 5,000 kg of which nearly 50% comes from France. The international market prices of jasmine concrete and absolute, in which forms the jasmine oil is commercially produced, are said to be around Rs 12,000/kg and Rs 19,000/kg respectively. Price fluctuations are common and normally premium prices are offered for high-grade products. The main buyers are the USA, the UK, Holland, Sweden, Norway, Japan and the USSR. The species of jasmine used in these countries is the Spanish jasmine (*J. grandiflorum*) and the variety used has pink streaks on the exterior of the petal lobes.

In the Tamil Nadu Agricultural University, Coimbatore, 15 species and 45 varieties of jasmines were collected and evaluated for concrete recovery. Of the three important species grown the concrete recovery of *J. grandiflorum* ranged from 0.25 to 0.32%. *J. auriculatum* recorded high recovery of concrete ranging from 0.28% to 0.36%. But *J. sambac,* the species grown largely, yielded only very low percentage of concrete the recovery ranging from 0.14% to 0.19% (Table 1).

Table 1. Flower yield (kg) and floral concrete recovery (%) in different species of jasmine (Abdul Khader *et al.*, 1984)

Species	Yield of flowers (kg/ha)	Concrete recovery (%)
J. auriculatum Range for 5 clones	4,733 to 9,152	0.28 to 0.36
J. sambac Range for 6 clones	739 to 8,129	0.14 to 0.19
J. grandiflorum Range for 6 clones	4,329 to 10,144	0.25 to 0.32

It is to be noted here that the concrete from *J. grandiflorum* alone has international market. In a varietal evaluation programme six clones of *J. grandiflorum* were evaluated for their yield of flowers and concrete. A secondary selection from Lucknow clone was found to yield over 10 tonnes of flowers per hectare with an estimated concrete yield of 29 kg, the

recovery being 0.29%. This selection was released by the Tamil Nadu Agricultural University as 'Co 1 Pitchi'.

The jasmine concrete is a wax-like substance containing the natural flower perfume as a volatile oil, together with some plant waxes and albuminous and colouring matter. Steam distillation for the extraction of the volatile oil is of no avail. Hence the solvent extraction method is practised in which the odoriferous substances of the flower are allowed to be absorbed by a highly volatile solvent and then the solvent is evaporated leaving behind the odoriferous principles.

For extraction of concrete only freshly-picked fully-opened flowers are required. The fully-opened flowers have to be picked early morning preferably before 9.30 a.m. Delay in picking beyond 9.30 a.m. results in gradual reduction of concrete yield. Picking the flowers after 11.00 a.m. will considerably reduce the yield and quality of the concrete.

Food-grade hexane, perfumery-grade hexane, petroleum, ether and carbon tetrachloride have been tried as solvents. Perfumery-grade hexane was found good but proved very costly. Carbon tetrachloride gave better and quicker extraction than food-grade hexane. But owing to its high cost and inflammable nature its use is also limited. Food grade hexane with a boiling point of 60° to 80°C, was found satisfactory. But the food-grade hexane available in the market has several impurities and has to be purified before use. Addition of liquid paraffin at 5% and distillation at 70°C gave a fairly good grade hexane suited for floral concrete extraction (Sambandamurthi and Abdul Khader, 1982). For the rotary type of extractor designed by the Tamil Nadu Agricultural University, Coimbatore, the optimum requirement of solvent per kilogram of flowers was found to be 2 litres of food-grade hexane. For static type of extractors the solvent requirement is still higher. For every kilogram of flowers about four to five litres of hexane will be required.

After the complete extraction of the perfume from the flowers, the solvent is filtered and concentrated by evaporation at a constant temperature of 75°C. At this temperature the solvent evaporates leaving the perfume and other plant waxes. The vapour of the solvent is condensed into liquid again for recycling. The concentrated liquid contains the perfume, wax, pigments and the solvent is distilled in a vacuum distillation unit where the complete removal of the solvent takes place leaving the floral concrete in the form of molten wax.

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10

Orchids

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ORCHIDS, the most beautiful flowers in God's creation, comprise a unique group of plants. Taxonomically, they represent the most highly evolved family among monocotyledons with 600–800 genera and 25,000–35,000 species (Garay, 1960; Arditti, 1981). Orchids exhibit an incredible range of diversity in size, shape and colour of their flowers. They are most pampered of the plants and occupy top position among all the flowering plants valued for cut flower production and as potted plants. They are known for their longer lasting and bewitchingly beautiful flowers which fetch a very high price in the international market.

Theophrastus, who is also called the father of Botany (370–285 BC), gave the name 'Orchids' to the group of bizarre plants on the basis of the resemblence of paired underground tubers of these plants to masculine anatomy (the testes). This resemblence was also responsible for the mistaken belief that the orchids possess aphrodisiac properties and eating of underground tubers might 'provoke venus' and they may beget male children.

In the Indian Vedic scriptures there is a mention of the plants under the name 'Vanda', which has been adopted as a generic name in one of the most beautiful group of orchids.

Most of the orchids are perennial herbs with simple leaves. Although, the specialized flower structure conforms to a standard plan, the vegetative parts show great variation, a large number of them being epiphytes, or terrestrial and a few saprophytes and leafless in nature (Larson, 1980).

Majority of the cultivated orchids are native of tropical countries and occur in their greatest diversity in humid tropical forests of South and Central America, Mexico, India, Ceylon, Burma, South China, Thailand, Malaysia, Philippines, New Guinea and Australia. Brazilean cattleyas, Mexican laelias and Indian dendrobiums, cymbidiums and vandas have played a major role in the development of modern orchid industry in the world.

The evolution of orchid culture from hobbyist to commercial grower was

very slow as most of the orchids collected from different regions did not adapt to local conditions and died. The methods of propagation were not known and most of the orchids which flowered under utmost care were found to be self sterile. Further, it was difficult to germinate the seeds, which lack any functional endosperm. The seeds sown in the nursery beds required long period of germination and any disturbance to the soil or physical environment destroyed the whole population (Northen, 1970).

It was only in 1821 when Conrad Loddiges and Sons started growing orchid plants commercially at their nursery in Hackney (Larson, 1980), followed by John Daminy of M/s Veitch & Sons who produced the first orchid hybrid between two *Calanthe* species in 1852, which flowered in 1856 in Veitch Nursery Exeter, England (Withner, 1959). This was followed by a large number of man-made hybrids produced by hobbyists and small growers. In 1913, Sun Kee Nursery, Singapore, started the first cut-flower production of *Arachnis* type hybrids.

The major developments in the cultivation of orchids in the world have been due to modern scientific technology which has been suitably used in case of orchid seed germination and meristen culture (Chadha and Singh, 1985).

Today orchids are grown on assembly-line method in extensive glass-houses with controlled environment and the sale of orchid flowers runs in millions of dollars. Thailand alone exports *Dendrobium* sprays worth more than $ 12 million to Europe and West Germany. Orchid flower sales in USA for internal consumption alone are valued at US $ 50–60 million (Rao, 1977). The annual value of export trade in Singapore in 1974 exceeded US $ 2.3 million. The modern methods of propagation have brought orchid cultivation on par with other commercial crops.

ORCHID RESEARCH IN INDIA

Orchid Flora

Orchids form 9% of our flora and are the largest botanical family of higher plants in India (Jain, 1980). It is estimated that about 1,300 species (140 genera) of orchids are found in our country with Himalayas as their main home and others scattered in Eastern and Western Ghats. The following is the distribution of orchid species in different regions of India (Jain, 1985).

North-Western Himalayas	ca 200 species
North-Eastern India	ca 800 species
Western Ghats	ca 300 species

North-Eastern India owing to its peculiar gradiant and varied climatic

conditions contains largest group of temperate, sub-tropical and tropical orchids.

India has a very large variety of orchids and hilly regions have one or the other orchid flowering almost throughout the year. The diversity is so large that there are large-flowered, small-flowered, terrestrial, epiphytic and also saprophytic orchids. In general terrestrial orchids are more common in North-Western India, epiphytic orchids in North-Eastern India and small-flowered orchids in Western Ghats. The largest terrestrial genus is *Habenaria* (ca 100 spp.) and the largest epiphytic genus is *Dendrobium* (ca 70 spp.). Most of the *Paphiopedilum* (Lady's Slipper) species are restricted to N.E. Himalayas except for *P. druryi* which has been reported from Kerala but now is almost extinct from its original habitat.

Some orchids are endemic to India and are not found any where else in the world. They are *Cryptochilus, Anthogonium, Risleya, Sirhookera* and *Cleisocentron.*

Some of the Indian species are so ornamental and in demand that their natural populations have been over exploited. Some species in the genera like *Arundina, Cymbidium, Coelogyne, Dendrobium, Paphiopedilum, Renanthera,* and *Vanda* are almost extinct. The provisional list of 150 endangered plants of India includes many orchids like *Acanthephippium sylhetense, Anoectochilus sikkimensis, Aphyllorchis montana, Arachnanthe clarkei, Arundina graminifolia, Cymbidium macrorhizon, Dendrobium densiflorum, Didiciea cunninghamii, Eria crassicaulis, Galeola lindleyana, Gastrodia exilis, Paphiopedilum faireanum, P. cordigerum, P. druryi, Pleione humilis, Renanthera imschootiana, Vanda coerulea, V. pumila and V. roxburghii.*

The list of plants banned or restricted for export from India formerly included a few orchids but now include all orchids growing wild. The Convention of International Trade in Endangered Species of wild Fauna and Flora (CITES), ratified by India, places all species of Orchidaceae under Appendix II, meaning thereby that their trade will be only through export permits.

Steps have also been taken to conserve Indian native species by establishing orchidaria, sanctuaries and germplasm conservation centres. Botanical Survey of India has established two orchidaria one at Shillong and other at Yercaud to conserve rare and endangered species. The ICAR research complex at Shillong, the Indian Institute of Horticultural Research at Hessaraghatta and the Indian Botanic Gardens at Calcutta maintain collections of orchids in their orchidaria. Some states have also established orchid sanctuaries in Sikkim at Singtom and Deorali and in Arunachal Pradesh at Tapi.

INDIAN ORCHIDS

Some of the Indian orchid species which are of high ornamental value

are: *Aerides crispum, A. fieldingii, A. multiflorum, A. odoratum, Anaectochilus roxburghii* (Jewel orchid), *Arachnis clarkei, Arundina graminifolia, Bulbophyllum leopardinum,* (Button hole orchid), *Calanthe masuca, Coelogyne elata, C. devonianum, Cymbidium pendulum, C. longifolium, C. munronianum* (scented cymbidium), *Dendrobium aggregatum, D. aphyllum, D. barbatulum, D. chrysanthum, D. farmeri, D. densiflorum, D. devonianum, D. fimbriatum, D. jenkinsii, D. moschatum, D. nobile, Paphiopedilum faireanum* (Lady Slipper orchid), *P. venustum, P. hirsutissium, P. insigne, Phaius wallichii, Pleione praecox, Rhynchostylis retusa, Thinia alba, Vanda cristata, V. coerulea,* and *V. coerulescens* (Figs. 1, 2).

Majority of the cultivated orchids are native of tropical climates and are found in abundance in India in the states of Assam, Meghalaya, West Bengal, Karnataka and Kerala. Kalimpong, Shillong, Trivandrum, Bangalore and Yercaud are the places most suitable for the cultivation of orchids. Kalimpong among these is called heaven for orchids.

Growing of orchids in India commercially is not organised and is still in the hands of hobbyist and few dealers who mainly depend on wild collections from forests to meet a large part of their foreign and local demands, due to which some of the orchid-growing areas are now without any orchid and very rare species are now facing the danger of depletion. It is only very recently that orchid growers like Ganeshmani Pradhan and U.C. Pradhan of Universal Nursery Kalimpong have taken up very systematic growing of orchids for local market and export.

CULTIVATION OF ORCHIDS

Types. Orchids can be divided into two groups—monopodial or sympodial depending upon their habit of growth. Monopodial orchids such as *Phalaenopsis, Renanthera* and *Vanda* have a main stem which continues to grow year after year producing inflorescence from the leaf axils. Sympodial orchids such as *Cattleya, Cymbidium,* and *Dendrobium* have a main stem which terminates growth at the end of each season. A new shoot (lead) then grows from the base forming its own bulbous stem called pseudo-bulb which eventually flowers.

The pesudo-bulbs or thickened stems are very useful devices for the storage of food and water and function like bulbs.

In addition to the epiphytic orchids, there are also ground orchids or terrestrial orchids which grow like ordinary plants with their roots in soil. Most of the temperate zone orchids are terrestrial and tropical orchids are epiphytes.

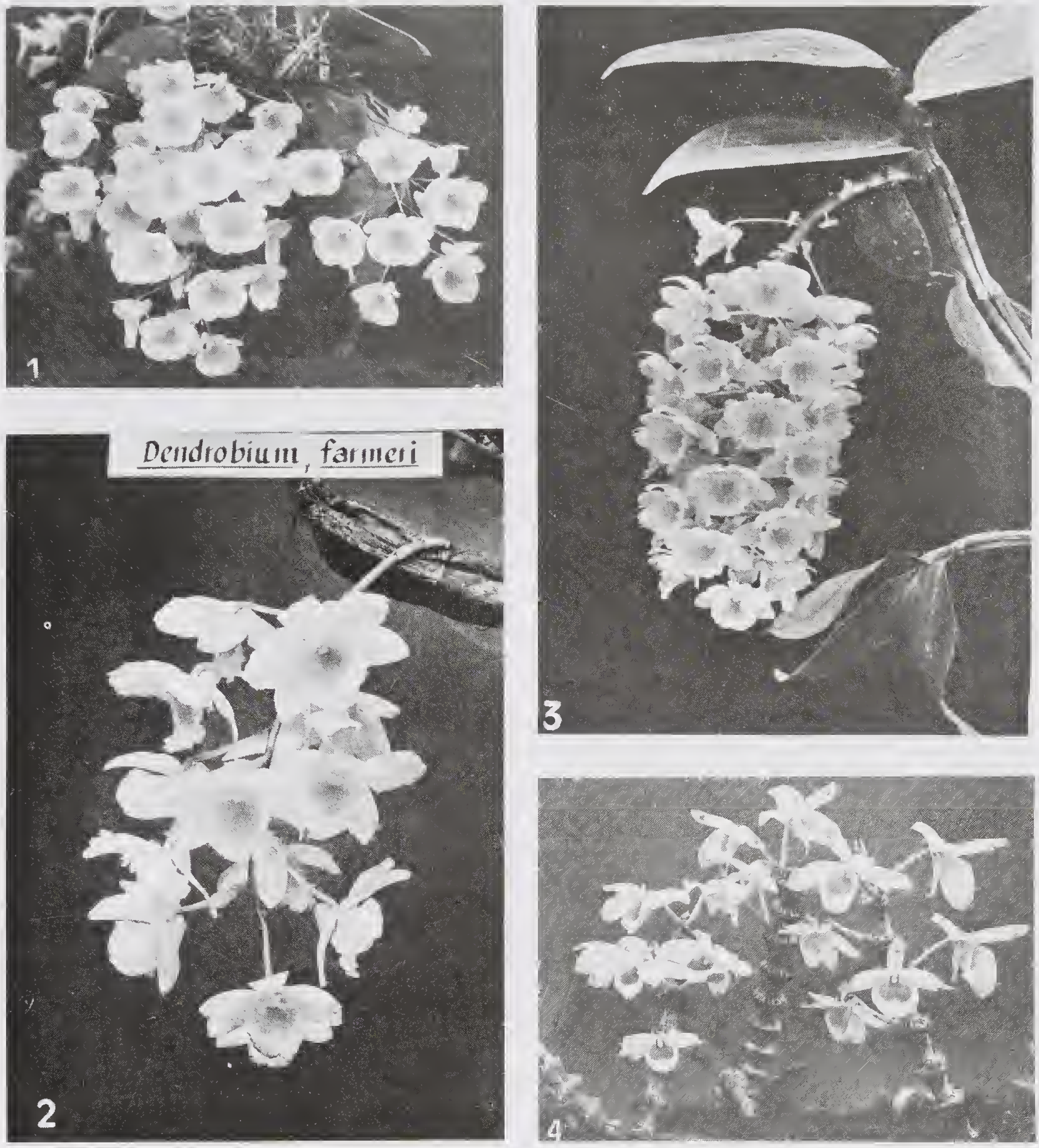


Fig. 1. Indian orchids: (1) *Dendrobium aggregatum,* (2) *D. fumeri,* (3) *D. densiflorum,* (4) *D. crassinode.*

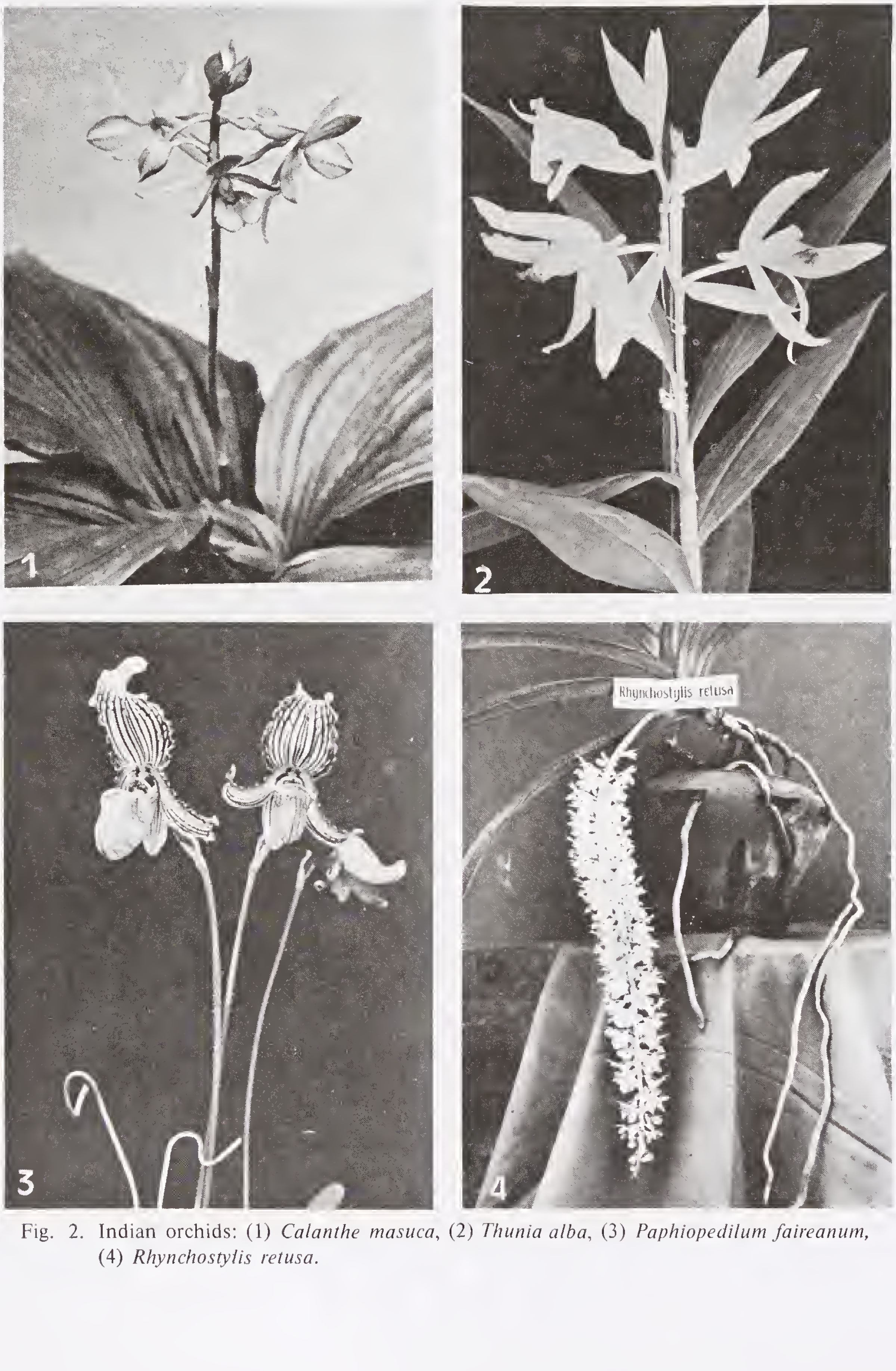


Fig. 2. Indian orchids: (1) *Calanthe masuca*, (2) *Thunia alba*, (3) *Paphiopedilum faireanum*, (4) *Rhynchostylis retusa*.

Orchid house. Orchids in nature grow protected from the tropical sun by the shade of trees. Under controlled conditions the orchids can be grown in specially designed orchidaria or orchid houses, running north and south and made from materials like split bamboo, glass, fibre glass, etc. A central tank filled with water helps in increasing the humidity. However, it must be clear that all types of orchids cannot be grown under one roof. While tropical orchids enjoy humid, warm atmosphere and burst into activity during rainy season, temperate orchids should be growing in cool houses. Orchids dislike sudden change in temperature, however a difference of 10°—20°C between day and night temperature is beneficial. The best suitable range is 18°C to 30°C, proper ventillation is must to provide fresh air and also helps in reducing the temperature.

There are also orchids which can be grown in open sun. Various terete-leaved species of *Vanda, Aranda, Arachnis, Renanthera* etc. can be grown in open trenches filled with brick pieces, charcoal, as is done in Ceylon, Singapore and Thailand.

Light. Indirect sunlight is ideal for orchids. Seedlings require less light than adult plants. Very poor light tends to produce weak plants and retards flowering. A plant which has been grown in the shade should gradually be shifted to sunlight.

The optimum requirement of light varies between species to species. *Cypripedium* and *Phalaenopsis* require only 200–300 foot-candles. Whereas genera like *Vanda* and *Aranda* thrive best under 800 foot-candles (Abraham and Vatsala, 1981). Majority of the orchids are day neutral and are not influenced by day length. But in *Cattleya* both short-day and long-day plants are met with.

Dodson (1962) while experimenting with filtered sunlights has reported that filtered sunlight stimulates formation of male flowers in *Catasetum* while in direct sunlight only female flowers are produced.

Humidity/watering. Humid, warm atmosphere is most essential for the growth of most of the tropical orchids, which do not have well established root system. It is a good idea to have a water tank or pool in the centre of the orchidaria to maintain humidity, which should not be less than 30% at night and 80% during day time. The plants should be watered 2–3 times a day and should not be allowed to dry up during hot climate. Plants in active growth require more water. Similarly plants in baskets require more water than those in pots. Care should be taken to water the plants with a fine spray by using standard nozzles and not to hit the plants with powerful jets of water.

Plants which are freshly potted should be watered very sparingly till the new roots appear and watering should be gradually increased.

Pots/containers. Orchids should be potted in small containers/pots according to the size of the plant. As a thumb rule, orchids should be under potted to get more flowers. Any kind of pots/container which can hold the medium and provide aeration is suitable. Most of the people prefer plastic pots which retain moisture longer than mud pots. Vandaceous and Sarcenthene orchids can be grown in teak-wood baskets. Orchid plants should not be disturbed frequently and repotting done only when absolutely necessary. Orchids like *Cymbidium,* react favourably when repotted after 2–3 years whereas Vandaceous orchids and *Paphiopedilum* should not be disturbed unless very necessary.

Terrestrial orchids, like *Spathoglottis, Phaius* and *Calanthe*, should be grown in 20–25 cm pots with 1:1:1 mixture of leaf mould, FYM and sand. For *Paphiopedilum* a mixture of 2 parts leaf mould, 2 parts loam soil and 1 part each of brick pieces and charcoal is recommended (Rao, 1985).

Experiments conducted at Botanical Survey of India, Calcutta, have revealed that in case of *Rhychostylis gigantea*, chunks of hard-wood charcoal alone as potting substrate were superior than eleven other potting media (Bhattacharjee, 1985). Tree fern fibres also performed better than the other media while coconut husk and over-burnt brick as planting substrate had adverse effects on growth and flowering of *R. gigentea* plants. Some latest media tried for growing orchids are gravel jelly, fir bark, tree fern fibre, and polyurethene foam.

Manuring. In nature, orchids obtain their supply of inorganic nutrients like calcium, magnesium, iron, potassium, nitrogen and traces of manganese, boron, copper, zinc etc. from the bark of the tree on which they are growing and also from atmosphere and decaying vegetables and droppings of birds. However under controlled conditions they have to be supplied with all these major and minor nutrients.

Taking into consideration the special need of different orchids, a large number of fertilizer mixtures, both solid and liquid, are available in market. Liquid fertilizers are much more quickly absorbed and can be applied more frequently. As the orchids are slow growing, slow release fertilizers like osmocote can be used to get very good results. Usage of fertilizer should also depend on the stage of growth. During vegetative growth, large quantities of nitrogen are required while during flowering, nitrogen should be reduced and amount of phosphate increased. One of the most common liquid fertilizer for epiphytic orchids is Ohio WP solution (Northen, 1970), the composition of which is given below.

Composition of Ohio W P solution fertilizer (g)

Potassium nitrate KNO_3	2.63
Ammonium sulphate $(NH_4)_2SO_4$	0.44

Magnesium sulphate $MgSO_4$ $7H_2O$	2.04
Monocalcium phosphate $Ca_4(PO_4)$ H_2O	1.09
Calcium sulphate $CaSO_4$ $2H_2O$	4.86
Ferrous sulphate $FeSO_4$ $7H_2O$	0.5
Manganese sulphate $MnSO_4$	make 1% solution and use 2.5 cc
Water	4 litres
Use the above solution in half strength	

Prof. Abraham of Tropical Botanic Garden has been getting excellent results by using inorganic fertilizer mixture (NPK 20 : 20 : 20) with trace elements and coconut water (20–25%) applied every week for three successive weeks followed by a 10 : 30 : 20 (NPK).

In general, pH of the nutrient solution should be slightly acidic or neutral but not alkaline.

Diseases and pests. Like all other plants orchids are also prone to a number of diseases caused by fungi, virus, bacteria, insects and pests. The most common diseases in each group are:

FUNGAL AND BACTERIAL DISEASES

Leaf spot—caused by *Colletotrichum* and *Gleosporium*
Leaf blight—caused by *Pythium*
Collar blotch—caused by *Penicilium thomii*
Collar rot—caused by *Sclerotium*
Orchid wilt—caused by *Sclerotium rolfsii*

Various fungicides like Captan, Dithane, Agrosan, and Ceresan are very effective against these diseases.

VIRUS DISEASES

More than 32 diseases are known to occur on orchids. In some cases the same virus has been known to produce more than one disease in different species, the most common are *Cymbidium* mosaic virus (CYMV), *Odontoglossum* ring spot virus (ORSV) and *Dendrobium nobile* mosaic virus (Den Mv).

As control measures all infected plants should be isolated to prevent spreading of the disease.

INSECT PESTS

The most commonly reported insect pests on orchids are thrips, aphids, spidermite, soft scale, mealy bugs, orchid weevil, snail and slugs. These insect pests harm the plants in many ways. They feed on tender young shoots, suck the sap and damage the young buds and shoots and also act as carriers of different diseases.

Fortunately all these can be controlled by effective insecticides like

Parathion, Malathion, BHC, Aldrin, Dieldrin, etc. Metaldehyde has proved to be very effective in killing slugs and snails.

PROPAGATION

Orchids, like other horticultural crops, may be propagated either sexually or asexually. Since most of the commercial orchids are highly heterozygous they are not raised through seed and are propagated through vegetative means to get true-to-type plants. Conventional methods like cuttings, division of shoots or Keikis, are followed along with mericloning through tissue-culture techniques.

Vegetative Propagation

Cuttings. Orchids like *Aerides, Arachnis, Epidendrum, Renanthera, Phalaenopsis, Vanda* and *Dendrobium* (nobile type) can be propagated by cuttings. Orchid cuttings are usually much bigger (8–12 cm long) and should possess one or more roots. Cuttings are usually potted in propagation beds or directly in pots after treating the cut ends with fungicides to prevent rotting.

Cuttings of the genera, like *Aerides, Arachnis, Vanda* etc., are very hardy and can be directly potted in pots, whereas those of *Dendrobium* (nobile type) and *Phalaenopsis* need special care to root and should be potted in propagation beds.

The propagation of orchids through cuttings is getting popular again and some of the nurserymen like to propagate their orchids through cuttings to get uniform plants. The percentage of variation (mutation) through this method is almost nill as compared to *in vitro* propagation through tissue culture. Further some orchids like *Anaectochilus* respond more to vegetative propagation through cuttings than any other method.

In 1983 Goh has very successfully demonstrated that the rooting of the *Aranda* 'Wandy Scott' can be influenced by treating the cuttings with different concentrations of NAA.

Most of the sympodial orchids, like *Coelogyne, Cattleya, Dendrobium* and *Cymbidium*, are propagated through this method. The method involved consists of dividing large clumps into smaller units. However, care should be taken not to divide the plants unless there are 8–10 pseudo-bulbs. Dendrobiums which are very fast growing can be divided every year.

In 1986, Nagabhushan and Singh studied the effect of different growth regulators on the rooting of old back bulbs of *Dendrobium aggregatum* var. *majus*. It was observed that IBA (2000 ppm) induced maximum rooting (87%) followed by NAA and IAA.

Off-shoots and Keikis. In some monopodial orchids, like *Ascocenda* and *Phalaenopsis,* Keikis or off-shoots emerge frequently on the main stem. This usually happens when the apex has lost its effectiveness in suppressing axillary buds. In most of the commercial orchid nurseries topping of the stem is commonly practised to induce Keikis formation.

Induction of Keikis can also be induced through the use of cytokinins which forced the dormant buds to develop into Keikis (Kunisaki, 1975).

Stewart and Button (1977) studied the effect of Benzyladenine (BA) on the development of lateral buds in *Paphiopedilum.* They observed that single application of BA 1 mg^{-1} is adequate to stimulate the development of axillary buds from near the stem bases. This helps in getting more number of lateral buds for propagation of difficult-to-propagate genera like *Paphiopedilum* which do not respond much to tissue-culture techniques.

Aerial shoots. Most of the dendrobiums produced aerial shoots or bulbs on old back bulbs devoid of leaves. They usually arise on the upper part of the back bulbs and grow out slowly. These aerial shoots take 90 to 120 days to develop roots. At this stage, they are detached along with a portion of back bulb and potted as independent plant.

In genera like *Goodyera*, the rhizome gives off special lateral branches which turn up and produce aerial shoots (Abraham and Vatsala, 1981). When they are properly rooted they get detached from the mother plant and establish separately.

Other methods. In few genera, like *Peristylus*, and *Nervillia*, the roots are produced from above the tubers, each of which ends in a tubercle. These small tubers produce new plant the year after (Abraham and Vatsala, 1981).

Vanda and other monopodial orchids can also be multiplied by air-layering or marcotage. A cut is given through the stem 20 to 25 cm below the apex and moist sphagnum moss is wrapped around the cut portion. The rooting media is kept moist and once the roots are formed, the layer is removed from the mother plant and potted in small-sized pots.

ORCHID IMPROVEMENT

Flower and reproduction. The orchid flowers are irregular, extremely variable in size and shape with sparkling texture. They may be solitary or in spikes emitting the fragrance of lemons, cloves or fresh lavender oil. A few are, however, highly malodorous.

The flower has its parts in threes, i.e. 3 sepals and 3 petals collectively called as tepals due to their resemblance in texture and colour, similar to each other and subsimilar to sepals. It is, however, the third petal

which is different and distinctive and is called labellum or the lip. The lip which is highly polymorphous is responsible for the different names of the orchids like 'Frog orchid', 'Dove orchid', 'Spider orchid', 'Lady slipper orchid' etc.

The reproductive organs of the orchids, the stamens and the pistil, are condensed and form a consolidated complex body, the column (gynostegium), the male and female part being separated by a flap or projection of a tissue called rostellum.

Orchids are cross-pollinated by insects and birds and to achieve this they have adopted many contrivances like mimicry and twisting of the flower on its stalk to almost 180° to face its pollinating agent (resupination). A fine example of mimicry is shown by a Mediterranean orchid *Ophyrus*. It resembles a female wasp and emits a similar odour to attack the male wasp. In this attempt to mate with the plant, the male wasp picks up the pollinia and eventually deposits it on another flower.

A large number of natural hybrids both intergeneric and interspecific have been reported in different genera like *Odontoglossum, Phalaenopsis, Cattleya, Laelia, Miltonia* and *Oncidium*. *Cattleya guatemalensis* collected from Gautemala in 1861 by Skinner was found to be a natural hybrid between *Epidendrum aurantiacum* and *Cattleya skinneri*. It was later named as *Epicattleya*. Similarly, *Phalaenopsis intermedia* is a natural hybrid between *P. aphrodite* and *P. rosea*.

Breeding of new varieties. Since 1856 when the first orchid hybrid *Calanthe dominyi (C. masuca × C. furcata)* flowered, a very large number of artificial hybrids have been produced both at intergeneric and interspecific level. To date, more than 45,000 hybrids have been registered with an average of 1,000 more every year.

The success and ease with which such a large number of hybrids are produced every year depends upon the fact that most of the orchid genera and species have no genetic barriers and they cross freely with each other. It must be mentioned that most of the orchid genera are still in the process of evolution and most of the orchid groups are in reality only artificial constructs. The other two factors which have played a major role in the development of orchid hybrids are polyploidy and introgressive hybridization. In some genera, like *Cymbidium, Paphiopedilum, Phalaenopsis, Cattleya, Laelia, Sophronitis,* polyploidy has been of extraordinary effect, and coupled with intergeneric compatability has culminated in the formation of hybrid groups which show both greater size and hybrid vigour as compared to parental species.

The important genera which have given maximum number of man-made hybrids are *Cattleya, Cymbidium, Paphiopedilum, Vanda, Dandrobium* etc. Some of the important intergeneric hybrids are:

Ascocenda (Ascocentrum × Vanda)

Aranda (Arachnis × Vanda)
Aeridovanda (Aerides × Vanda)
Brassocattleya (Brassovola ×Cattleya)
Vandaenopsis (Phalaenopsis × Vanda)
Laeliocattleya (Cattleya × Laelia)
Sophrocattleya (Cattleya × Sophronitis)

A few other hybrids evolved for cut flower production on commercial scale are (Kamemoto, 1980) (Fig.3).

Arachnis—'Maggie Oei'
Aranthera—'James Storie'
Aeridochnis—'Bogor'
Aranda—'Wendy Scott'
Aranda—'Christine'
Dendrobium—'Pompadour'
Dendrobium—'Walter Oume'
Dendrobium—'Tomie'
Dendrobium—'Spell Bound'
Dendrobium—'Caesar'
Vanda—'Miss Joaquim'
Vanda—'Rothschildiana'
Ascocenda—'Yip Sum Wah'
Oncidium—'Golden Shower'

The above hybrids are very well suited for Indian climatic conditions and can be grown on commercial scale.

SEED GERMINATION

Seed structure. The most interesting and adaptive feature of the family Orchidaceae is the physiology of its seed germination (Arditti, 1977). Orchid seeds are unique in several respects. They are exceedingly small and dust like and are produced in very large numbers. As many as 1,300 to 4,000,000 seed per capsule are produced. Their colour may be white, cream, pale green, reddish, orange or dark-brown (Arditti, 1967) and have very diverse shapes. Clifford and Smith (1969) arranged all the orchid seeds in five different standard forms.

Orchid embryo consists of relatively undifferentiated, mostly isodiametric cells with dense granulated cytoplasm and lose their viability very fast. Singh (1981) has developed a rapid staining technique to ascertain the viability of different seed samples (Fig. 4).

Symbiotic seed germination. Under natural conditions, the orchid seeds germinate after being infected by a fungus (Smith, 1947), the orchid mycorrhiza

Fig. 3. Exotic orchids: (1) *Dendrobium* 'Pompadour', (2) *Vanda hybrida*, (3) *Cattleya trianae*.

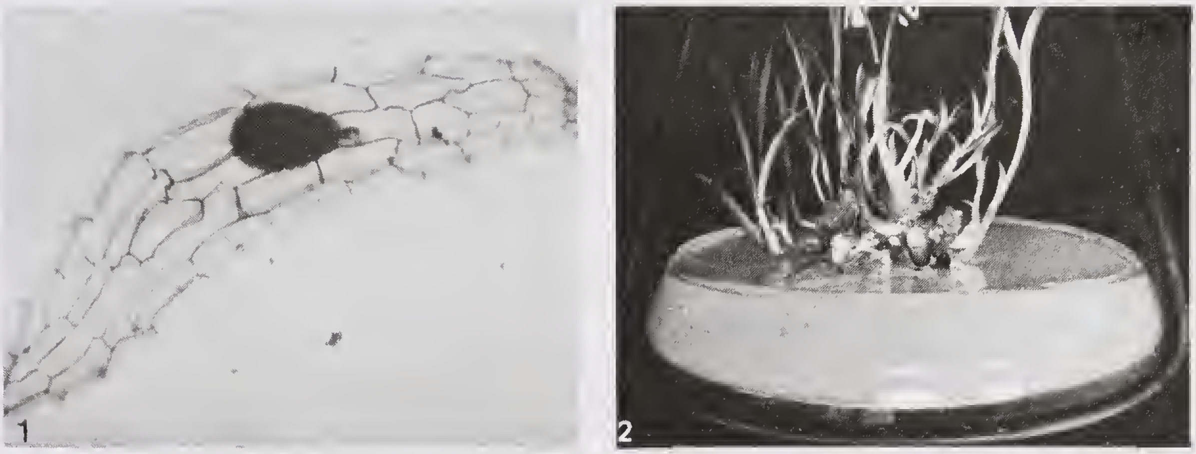
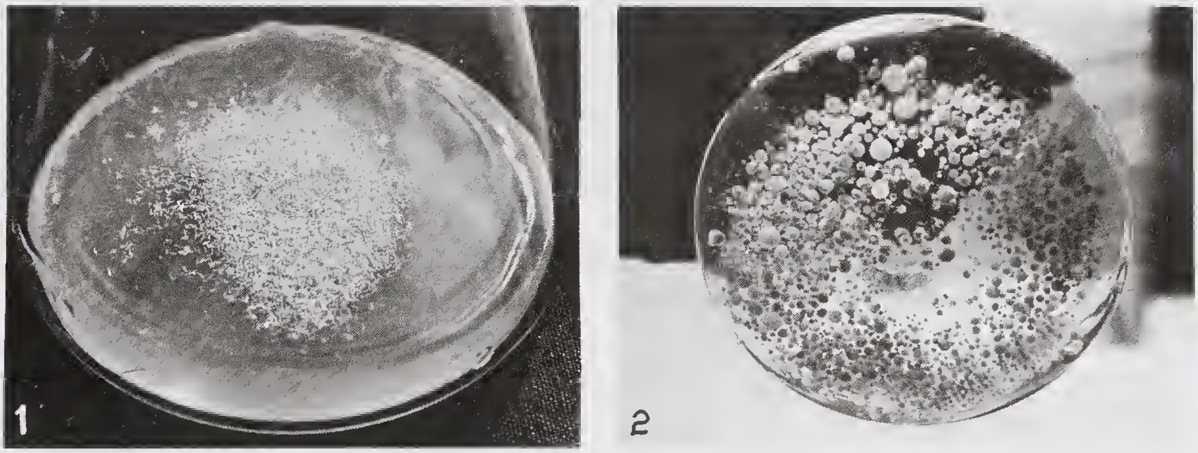


Fig. 4. Orchid seed germination: (1) Orchid seed showing embryo and seed coat, (2) Germinated orchid seedlings on VW medium.

Fig. 5. Suspension culture of orchid embryos: (1) *Epidendrum radicans* seed on solid VW medium, (2) Suspension culture showing faster germination.



which term was coined by Frank in 1885 (Mycorrhiza=Root fungus) (Withner, 1959).

Most of the mycorrhizal fungi of orchids fall into a non-sporing group known as *Rhizoctonia* (Arditti, 1981), the major species being *R. repens, R. mucoroides* and *R. languinosa.* Subsequent isolates were known as *Mycelium radicis.* For quite some time these fungi were called as Orcheomyces. Later on, however, other fungi were also isolated from orchid cultures. In Japan 54 different fungi were isolated from 20 orchid species (Nishikawa and Ui, 1976).

Orchid seeds cannot utilize their own reserves or do so very slowly, they can also not hydrolyse large molecules like starch or cellulose. As a result asymbiotic germination in the absence of sugar proceeds only to the early protocorm stage, after which they wait for the external supply of simple sugars through the help of mycorrhizal fungus.

Until the middle of 19th century European growers had no method for the germination of orchid seeds, and no hybrids could be produced, the only method followed was sowing of seeds at the base of the mother plant but in most of the cases the seeds either did not germinate, got mixed up or took too long to germinate. This was later followed by Bernards method (Bernard, 1909) in which culture tubes were inoculated both with seed and fungi but the method was very elaborate and left much to be desired.

Asymbiotic seed germination. While working on the influence of carbohydrates on green plants, Lewis Knudson in 1916 also started experimenting with the germination of orchid seeds (Withner, 1959) on the basis of the analysis of orchid salep which contained starch, protein, sugars and minerals, he formulated a medium and successfully germinated seeds of *Cattleya, Laelia, Epidendrum* and concluded that fungus was not necessary for orchid seed germination.

This was the breakthrough in orchid seed germination and was followed by others who tried to improve the original media of Knudson in order to germinate other orchid species.

When the seeds are planted on a nutrient medium *in vitro* not only the percentage of germination is improved in some cases to 100% but it also takes less time for further development. It may be mentioned here that an orchid seed while growing differentiates both bio-chemically and morphologically (Fig 4).

Different media. Since the advent of Knudsons medium, a large number of modified media have been standardized and are available in market even with pre-adjusted pH. The most common media used are Knudsons C. medium and Vacin and Went medium, the composition of both these media are given in the following pages (Table 1).

Table 1. Composition of Knudson C. Medium

Components	Quantity
Calcium nitrate, Ca $(NO_3)_2$ $4H_2O$	1,000 mg
Monopotassium phosphate. KH_2PO_4	250 mg
Magnesium sulphate, Mg SO_4 $7H_2O$	250 mg
Ammonium sulphate, $(NH_4)_2$ SO_4	500 mg
Ferrous sulphate, $FeSO_4$ $7H_2O$	25 mg
Manganese sulphate, $MnSO_4$ $7H_2O$	7.5 mg
Sucrose	20 g
Distilled water to make up to	1,000 ml
Agar	9 g

Most of the orchid seed germination media are solid. Recently Singh and Prakash (1985) have developed a new technique of suspension culture for the growing of orchid embryos in liquid media (Fig. 5).

In addition to standardizing media for different species, effect of different growth regulators, auxins, additives etc. have been investigated (Sangamma and Singh, 1986).

Composition of media. Different media range from simple three-salt solutions to complexes containing 20 or more salts. Some media are designed for specific genera like *Paphiopedilum*, while others for a broad spectrum. Sugars, are the most common carbon source in different media. Most of the orchids utilize disaccharides such as sucrose. Some of the species of *Cymbidium*, however, prefer glucose to sucrose. After a certain stage of germination the orchid seedlings do not require any exogenous supply of sugars.

Appropriate sources of nitrogen are the essential features of a balanced medium. It may be given in the form of nitrates, ammonia, urea etc. Auxins were the first growth hormones added to the orchid cultures (Withner, 1947) in majority of cases. IAA, IBA and NAA enhance seed germination and seedling growth. Bose and Mukherjee (1974) found that Knudson C.supplemented with 1 ppm NAA or IAA resulted in callus formation in *Vanda* seeds.

Cytokinins have different effect on different species (Arditti, 1967). BAP (Benzyl amino purine) has known to retard development and differentiation of *Cymbidium* protocorms.

Chennaveeriah and Patil (1975) have reported that germination of *Spathoglottis plicata* was maximum on the medium supplemented with casein hydrolysate, coconut water, 2, 4-D, IAA and NAA.

Among vitamins, thiamine only appears to be essential. Pyridoxine, nicotinic acid and myo-inositol frequently improve cell growth.

Micro-elements like boron, cobalt, copper and iodine are known to induce faster growth in orchid seedlings.

A large number of complex additives like coconut water, banana pulp

peptone, tomato juice, salep honey and beef extract have been used in different media to see their effect on orchid seed germination. Withner (1959) reported that the addition of coconut water to the nutrient media enhanced seedling growth.

Singh and Prakash (1985) have reported that coconut water 150 ml (v/v) and banana pulp (100 g/l) was most ideal for the production of robust and healthy seedlings in most of the tropical orchids.

Preparation of media. All the components of a medium should be dissolved one at a time to distilled water. Finally agar is added and the solution is warmed till agar is dissolved. The pH of the media is maintained between 4.5 to 5.2 and the media is autoclaved at 15 lb pressure for 20 minutes.

Sowing of seeds and transplanting. Seeds are sown on the media under aseptic conditions. Seeds can be either sterilized or sown directly from the green capsules. After 15–20 days, the embryo starts swelling and after 30–35 days 2-leaf stage can be seen. At 4-leaf stage the seedlings are taken out of flasks and after thorough washing are planted in community pots in a 1 : 1 mixture of shredded tree fern fibre or charcoal.

TISSUE CULTURE

Tissue-culture techniques were applied to orchids in 1960 when Dr G. Morel, the distinguished French botanist, while trying to figure out a way to prevent virus in potatoes hit upon the idea that the techniques of tissue culture can be highly successful in cloning of orchids and to get virus-free plants. Since then the technique has been variously modified and extended from *Cymbidium* to 56 other genera (Conger, 1981).

This technique was carefully exploited by commercial growers for rare plants and hybrids which while could not be propagated by any other means, responded very well to tissue culture at a much faster speed. Vacherot (1966) of Vacherot and Lecoulfe firm in France has developed a new technique of virus-free plants of *Cymbidium.* Today tissue culture is preferred for commercial propagation of orchids. There are many laboratories which propagate orchid plants on commission basis and earn million of dollars (Reinert and Bajaj, 1977).

Medium. Both liquid and solid media (Arditti, 1977) are used for the orchid tissue culture. The explants after being isolated from the shoot are cultured in or on the desired medium. In most of the cases the simple media used for orchid seed germination are also used for tissue culture. The same nutrients are used for both liquid and solid media, with the omission of agar in the former.

Morel (1960) at first used Knudson C. medium for meristem culture of *Cattleya, Cymbidium, Dendrobium, Miltonia* and *Phaius.* Later, however, he reduced calcium nitrate substituting it by ammonium nitrate (Table 2). He also

Table 2. Composition of some important nutrient media used in orchid tissue culture (g)

Chemical	Knudson C. 1946	Morel 1965	Vacin and Went	Wimber 1963
Ammonium sulphate	0.50	1.00	0.50	0.50
Ferrous sulphate	0.025	0.025	–	–
Magnesium sulphate	0.25	0.25	0.25	0.25
Manganese sulphate	0.0075	0.0075	0.0075	–
Ammonium nitrate	–	0.50	–	–
Calcium nitrate	1.0	0.50	–	–
Potassium nitrate	–	–	0.525	0.525
Monopotassium acid phosphate	0.25	0.25	0.25	0.25
Dicalcium phosphate	–	–	0.20	–
Tricalcium phosphate	–	–	0.20	–
Potassium chloride	–	0.25	–	–
Ferric tartarate	–	–	0.028	0.03
Tryptone	–	–	–	2.0
Sucrose	20.00	20.00	20.00	20.00
Agar	17.50	17.50	16.00	12.00
Distilled water	1,000 cc	1,000 cc	1,000 cc	1,000 cc
Only inorganic salts are mentioned				

found out that plant extracts like tomato juice and coconut water at a concentration of 10% along with IAA, IBA or NAA were helpful in the subsequent growth especially after the division of protocorms. Sagawa (1966) used Knudsons C. medium along with Vacin and Went medium. Scully (1967) cultured explants of *Cattleya* on Vacin and Went medium which was modified by adding 15% (by v/v) coconut water.

Propagation material, explants. In sympodial orchids like *Cattleya, Cymbidium* and *Dendrobium*, a young shoot arising from back bulb provides suitable material for tissue culture. On longer shoots, there may be several axillary buds as well as the apical bud, while the monopodial orchids like *Vanda, Aerides, Phalaenopsis*, nodal sections, shoot apex, Keikis or offshoots or even flower stalk cuttings can be used. The other parts of the plant like leaf and root have also been used by various workers (Tabe 3).

Arditti (1977) has published a very comprehensive review of orchid tissue culture. Tanaka and Sakanishi (1977) also obtained protocorm like bodies (PLB) from leaf segments of *Phalaenopsis* on Ms medium. Stewart and Button (1978) were able to get callus from *Epidendrum* roots.

Singh and Prakash (1985) successfully propagated *Thunia alba* through the use of flower stalk cuttings. They were also able to get multiple plantlet formation in liquid Vacin and Went medium supplemented with IBA 2mgl^{-1}, NAA 0.5 mgl^{-1} and coconut water (15% v/v). The technique is well suited for other monopodial

orchids like *Epidendrum, Vanda,* etc. (Figs. 6, 7, 8).

Table 3. Propagation of orchids through tissue culture

Name of the species	Tissue used	Medium	Results
Arundina bambusifolia	Nodal sections from seedlings and from mature plants	Raghava and Torrey (1964)	Shoot and root development takes place simultaneously after 32-45 days.
Calanthe masuca	Nodal sections	Modified Vacin & Went (Intuwang & Sagawa, 1973)	Plantlets are formed directly after 45-55 days.
Cattleya hybrids	Lateral bud meristem	Modified Vacin & Went (Intuwang and Sagawa, 1973)	Meristem grows well in liquid medium on shaker and can be sub-cultured, transferred to solid medium to get protocorm like bodies which develop into plantlets.
Cymbidium hybrids	Explants from shoots growing on pseudo bulbs	Vacin and Went liquid (Sagawa, Shoji and Shoji, 1966)	Protocorm like bodies are formed after 8 weeks, which can be sub-cultured and put in solid medium for differentiation.
Dendrobium hybrids	Explants from new growth	Vacin and Went liquid (Intuwang and Sagawa, 1973)	Protocorm like bodies are formed within 3-4 months.
	Nodal sections with 12 dormant buds	Vacin and Went solid (Intuwang and Sagawa, 1973)	Plantlets are formed within 47-52 days.
	Flower stalk cuttings	Vacin and Went solid (Intuwang and Sagawa, 1973)	Plantlets are formed with 60-75 days.
Epidendrum radicans	Leaf tips	Murashige-Skoog, 1962 liquid	Callus is formed after 60-75 days. Plantlets are formed on solid K.C. medium
	Flower stalk cutting	Vacin and Went medium (Intuwang and Sagawa, 1973)	Plantlets are formed after 47-52 days.
	Nodal sections	Vacin and Went (Intuwang and Sagawa, 1973)	Plantlets are formed within 40-50 days.
Phalaenopsis hybrids	Flower stalk cuttings	Vacin and Went (Intuwang and Sagawa, 1973)	Plantlets are formed within 37-50 days.
Rhynchostylis retusa	Apical meristem from shoot tips	Vajrabhaya and Vajrabhaya (1970)	Explants are produced after 140-160 days
Vanda hybrids Terete type cv. 'Miss Joaquim'	Nodal sections	Vacin and Went (Intuwang and Sagawa, 1973) without sucrose	Plantlets are formed after 2-3 months
	Axillary buds	1. Vacin and Went (Intuwang and Sagawa, 1973)	Plantlets without roots are formed
		2. Whites medium	Roots are found

Fig. 6. Tissue culture of orchids–Use of flower stalk cuttings: (1) Flower stalk cutting, (2) Initiation of rose and elongation of shoot, (3) Young plantlet, (4) Multiple plantlet formation.

Fig. 7. Tissue culture of orchids: (1) Young mericlones in flask, (2) Transplanted mericlones in the field.

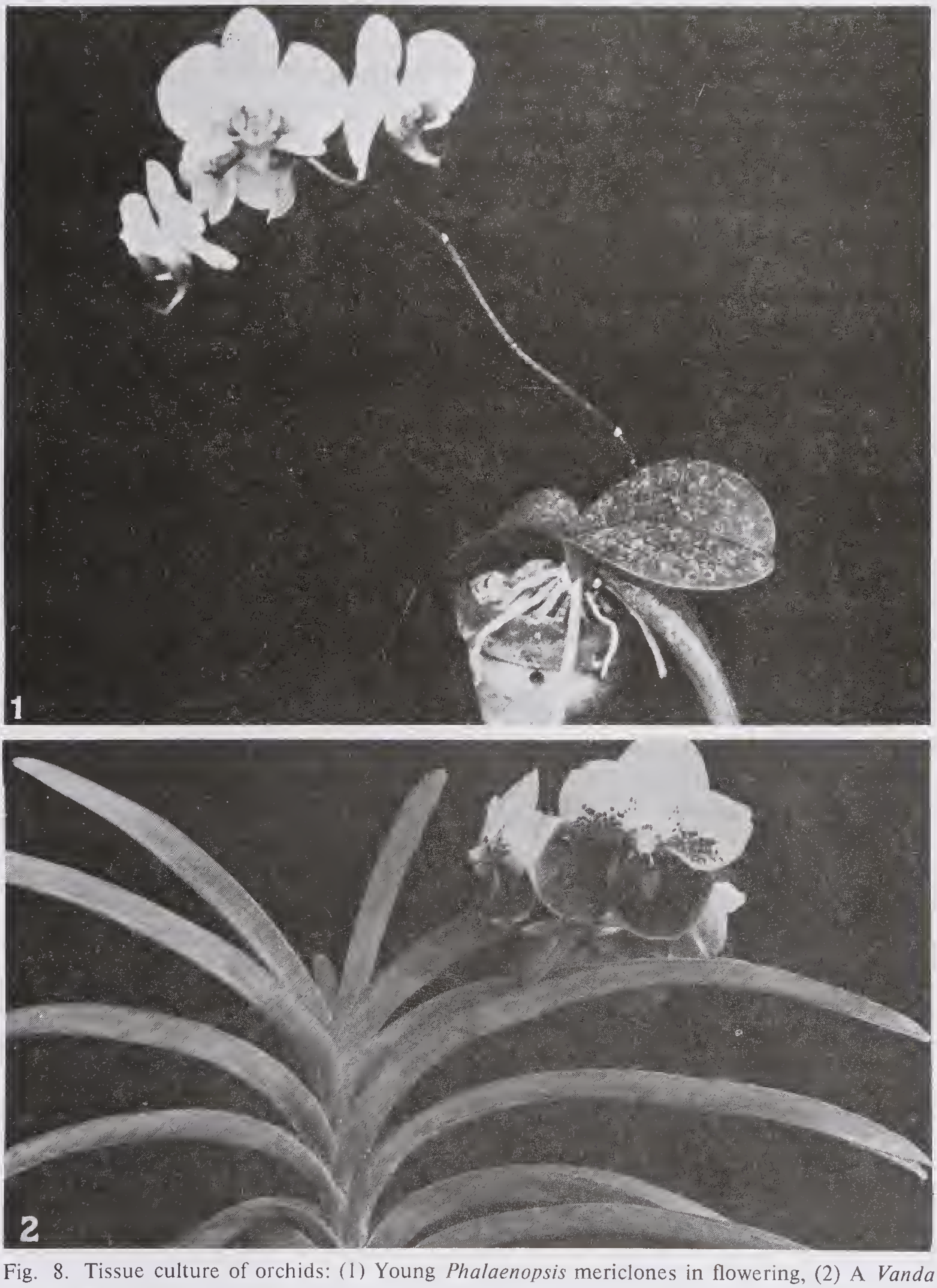


Fig. 8. Tissue culture of orchids: (1) Young *Phalaenopsis* mericlones in flowering, (2) A *Vanda hybrida* mericlone flowering.

DEVELOPMENT OF ORCHID INDUSTRY IN INDIA

The Indian orchid industry is not well organized. There are a few exporters from Kalimpong and Darjeeling and the sale does not exceed Rs 5,00,000 per annum. The value of the export can be increased considerably if the export is enhanced and well organised. Due to various climatic conditions which are available in India based on elevation and rainfall patterns, it is not difficult to grow different orchid species at different centres for commercialization.

The vital secret behind the commercialization of orchid lies with the orchid enthusiasts and hobbyists who are the ultimate buyers of the plant, and who always go for novelty, uniqueness and rarity. A species with moderate type of flower which is abundant in one region can be a piece of pride and create an aura of fascination in a different region where the species is introduced for the first time. There can be two broad categories for commercialization.

Sale of plant material. Novelty, uniqueness and rarity are the basic requisites for the sale of plants.

All available orchid species which have the above requisites should be collected, cultivated and properly identified. It has been observed that the selling rates of Indian species are not fixed and so a committee consisting of representative from growers and Government organizations should decide the price of each species for export. The present prices are too low and result in the loss of valuable foreign exchange.

Export of cut flowers. The cut flower industry in orchids is fast catching up and the cut flowers produced in tropical and sub-tropical regions are regularly exported to European and American countries. Singapore and Thailand export orchids to England and Germany.

In India some of the native genera, like *Cymbidium, Paphiopedilum, Vanda, Arachnis* and *Dendrobium*, can be grown on a large scale for cut flower production. Only those species should be selected for commercial flower production which flower in winter and spring as it is only during those months that India can capture the European and American markets. The best time of the year to export flowers to temperate regions is from December to May. The main pre-requisites of developing a successful orchid cut flower industry are (i) attractiveness and long shelf life of flower, (ii) high productivity and right season of bloom, and (iii) easy in packing and transportation.

Although the major aim for the development of orchid industry in India should be export oriented, the domestic market should not be neglected as the demand for orchid cut flower is likely to increase. Further action needs to be taken on the following lines.

Introduction of exotic species and hybrids. Instead of depending solely on the native species and hybrids it is recommended that a large number of modern

hybrids which are used for cut flower production should be imported. At present a lot of bottlenecks are imposed on the import of orchid hybrids such as currency restrictions, quarantine and custom clearance and often plants which are introduced through considerable effort and expense reach the indentors in non-viable condition. The procedure for the introduction of plant material should be simplified and the import of species and hybrids can be achieved through exchange of native germplasm as also with the help of foreign exchange generated from the sale of native species.

The imported species and hybrids should be carefully evaluated at different Indian centres before commercial multiplication. It is also recommended to import a large number of hybrid seedlings of outstanding parents in order to provide the diversity in genetic types for subsequent selection.

Breeding of Orchids

It takes on an average, 3–4 years from germination of seeds to first flowering. The production of new hybrids is therefore a long-term project.

In view of this it is necessary that care is excercised in the selection of parents for hybridization programme. Genera, like *Cymbidium, Dendrobium, Paphiopedilum,* which have their centre of origin in India, are likely to be more amenable to immediate genetic improvement both for sale of plant material and for cut flower than the exotic species.

The growing popularity of *Cymbidium* hybrids in the international market can be very well exploited by launching a well-planned breeding programme. Moreover, it is now possible to have cymbidiums in bloom from early October-June, a period when the *Cymbidium* cut flowers are in great demand in Europe. Demand can further be increased throughout the world if certain hybrids are produced which will flower well in warmer areas as the late bloomers are receiving considerable attention. *Cymbidium simonsianum* (a late blooming species) can be used as one of the parents for the production of late-blooming hybrids.

There is also very good scope for breeding of maniature cymbidiums which have a great demand in the international market. Fragrance is another important feature which can be exploited in *Cymbidium* breeding.

Standardization of Techniques for Embryo/Seed and Meristem Culture

The growing of orchid seed with the help of culture media has revolutionized the commercial orchid growing and hybridization, as every viable seed can be turned into a new plant. This has put orchid growing on par with other commercial greenhouse crops and has become a highly commercial proposition in countries like the USA, Europe, Thailand, Malaysia and Singapore. A few growers from Kalimpong and Bombay have started seed culture for the

propagation of different species. The meristem culture which enables the production of a much higher number of plantlets of the same clone in a short time as compared to old method of pseudo-bulb separation or off-shoot method has not been tried yet by any commercial grower in India.

Good work in this regard has been carried out by the Indian Institute of Horticultural Research, Bangalore, National Botanical Research Institute, Lucknow, and Bhabha Atomic Research Centre, Bombay. There is a strong need to start some more units for the propagation of orchids through meristem culture, and a selected group of orchid growers can be given training for the same at different centres.

Conservation of Indian Orchids

Deforestation through burning of forest trees (*Jhumming*) and falling of forest trees for timber have been the major cause for the depletion of our orchid wealth.

A large number of orchid species which were present in plenty in our forests are now at the verge of extinction and some of them have become so rare that a large number of botanical teams were unable to trace them. To cite an example *Paphiopedilum druryi* which was once found in plenty in Agastaya Hills in south is now difficult to locate and a stage has reached when we may be getting this very species from some foreign nurseries. Steps should therefore be taken to conserve our national wealth.

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11

Bonsai Culture

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BONSAI culture, a recent development in India, is an important branch of ornamental horticulture. The present-day garden in most residential areas may be barely of "postage-stamp size" and the garden lover reduced to exercising his skillls and love of plants in a balcony or on a terrace. In such a situation, a tree lover has to give up the idea of growing trees unless they are grown as bonsai which can be accommodated in a small space.

The history of bonsai is very old indeed, dating back to many centuries in China where it originated, as most Chinese arts, and from where it spread to Japan and became highly developed. In fact, bonsai culture is in the present day more known as Japanese than a Chinese art.

The idea that the Japanese and Chinese people convey to the rest of the world is of a small beautiful tree growing in a container as in nature, with all its parts performing their natural functions throughout the year. Indeed, the onlooker is under the illusion that the tree being observed is either a large adult or an ancient tree which has somehow been shrunk to occupy a small space. The keyword in this art is therefore 'illusion'; surely the tree cannot have the same number of branches, twigs or leaves as its adult in the ground and yet it appears to be a copy of such a tree. How does this illusion occur in the beholder's eye?

The answer to this question lies in the very detailed rules which have been formulated to enable the grower to develop a natural looking and beautiful tree growing in the small space of a container. There are many classifications of these rules but the simplest for a neophyte in the bonsai art is that in which the form of the future tree may be divided into styles according to the way in which it is grown, e.g. formal upright, informal upright, slanting, windswept, semi-cascade, cascade, broom, tree with more than one trunk, more than one tree planted as a group, rock plantings and mame ('baby') bonsai. The names of these styles are self explanatory and the rules are almost identical for many of them. The 'formal upright' style describes a tree which has spreading large roots on the surface of the soil, a straight tapering trunk, which when divided into three equal parts has the bottom one-third bare of branches, the middle one-third carrying the three or

four main branches and the top one-third is occupied by numerous small branches ending in the tip which may be pointed or rounded according to the type of tree grown. The main branches of an adult tree, contrary to a juvenile tree spread in a horizontal manner, slightly downwards or slightly upwards, therefore the three main branches in this style of bonsai will spread in like manner, one to one side, the other to the opposite side both slightly forwards and the third to the back of the tree giving the necessary appearance of depth and defining the front of the tree from which side it should be viewed. This style will be seen to depict a tree of conical shape. The trunk is visible fully in the bottom one-third and is seen partially through the main branches in the middle one-third and is not seen at all in the top one-third. The same basic rules will apply to the 'informal upright' and 'slanting' style but the trunk in the former style is not straight and in the slanting style, as its name implies is slanted. The 'windswept' style has the branches growing from one side of the tree, all swept in one direction by the force of the wind. The two 'cascade' styles have a similar arrangement of branches as in the first three styles except the branch to give depth is in front instead of to the back of the tree. These styles represent a tree growing over a cliff or a rock in a fountain-like manner. The trunk grows upwards for a short distance and then falls over the side of the container to a point above its bottom in the 'semi-cascade' style and below the bottom of the pot in the 'cascade' style. Other styles, as already mentioned are the 'broom' style where the branches grow approximately from the same spot on the trunk and spread in the form of an inverted broom, the 'multi-trunked' style, the group plantings of two or more trees, the 'rock' plantings and 'mame' or 'baby' bonsai. The 'rock' plantings are of two types; in one of which all the roots of the tree are accommodated in a hollow in the rock and the second type in which the roots clasp the rock and pass down into a container holding the rock and soil. The 'mame' bonsai is not more than 15 cm in height.

HOW TO START A BONSAI

The methods of starting a bonsai are the same as for any plant. A seed may be grown and the plant started on its bonsai career from an early stage, or cuttings, layerings or grafts may be made according to the type of plant being grown. A favourite way of starting a bonsai is to buy a suitable plant from a nursery and to shape it immediately into the particular style desired. A small ready-made bonsai may sometimes be dug up from rocky areas where the tree has been growing almost as a bonsai in a small space restricted by rocks. All these procedures for starting a bonsai are naturally undertaken during the growing seasons which vary slightly in different parts of the country but are roughly the spring season of February-March and the monsoon season of July-

August. An indication of when to start the bonsai is when the plant to be grown is budding. There are certain exceptions to these rules, for instance pines, plums, peaches if being grown in places other than the hills are not started in the monsoon but in the spring seasons and bougainvilleas are not planted in spring but in the monsoon season.

Soil. The soil used for a bonsai would resemble as much as possible the type of soil where the plant usually grows. It is better to use a soil of coarse texture in which the oxygen content is high and in which the drainage is adequate. The soil should be able to retain enough moisture to last for the plant until the next watering but should not remain waterlogged. Suitable compost would contain loam to which some leaf mould may be added as well as coarse builder's sand which will increase the porosity of the soil, and, therefore its draining properties. Steamed bone-meal as well as sludge in small quantities may also be added to the compost for flowering and fruiting tree.

Choosing a container. There are two important points to be borne in mind while choosing a container for a bonsai. Firstly, the drainage holes should be adequate for the size of the pot and secondly, in shape, size and colour it should harmonise with the tree being grown. Only then will it be aesthetically acceptable to the viewer. The dark earth colours are preferable to light or bright colours though these may sometimes be used for flowering and fruiting trees as matching or contrasting colour to the flowers or fruit. Considering the shape of the container, a rectangular or oval one is suitable for the 'formal upright', 'slanting' and 'windswept' styles and the tree is planted at the junction of one-third and two-thirds of its length. Other styles look well in round or square pots when the tree is planted approximately in the centre. Tall containers are used for the 'cascading' styles. The materials used for making containers are cement, clay and ceramic. Cement pots are apt to be heavy and clumsy unless carefully made. Terracotta clay pots are excellent for beginners as they are cheap. Ceramic pots are usually used for mature bonsai. Rocks and stones of various shapes and sizes are also used as containers and look natural and suitable to the subject if carefully chosen.

CHOICE OF PLANT

When selecting a plant to be grown as a bonsai it is essential to choose a variety hardy in the climate where it is to be grown. Besides this it is more appropriate to the small size of the bonsai to choose the type of tree which has small leaves, flowers and fruit. The leaves of many trees will reduce in size owing to repeated pruning of the bonsai but the flowers and fruits will not go smaller unless the bonsai has been underfed.

Among the conifers available to the enthusiast, there are very few which grow well in most climatic zones in this country. In the north, the *Pinus roxburghii*

Fig. 1. *Bougainvillea* 'Lady Mary Baring

Portulacaria afra are examples of these.

GENERAL ASPECTS

Selection of a plant. The purchase of a nursery plant for the purpose of

is hardy and grows well but will occasionally require a clipping of its needles which otherwise grow excessively long. In many parts of the subcontinent the *Juniperus prostrata* remains the ideal conifer for growing as a bonsai in most styles. Its only defect appears to be the slow thickening of the trunk. *Araucaria excelsa* may also be tried, though it is hardly a beginner's tree. The broad-leaved trees offer ample choice for the bonsai grower. The genus *Ficus* has many suitable species such as the *Ficus benghalensis* (*barh*) with its interesting aerial roots, *Ficus virens* (*pilkhan*) which is very easy to grow, *Ficus religiosa (peepal)* known to every one, *Ficus microcarpa* (*retusa*) with small leaves and *Ficus benjamina*—perhaps the best of all, which also has many suitable varieties. Besides these, there are many other species in this genus appropriate for bonsai including *Ficus carica* (the edible fig) which produces delicious fruit. In the same family there is the genus *Morus* (mulberry) which with care develops into beautiful bonsai. Other attractive plants are the peach and plum which flower and fruit in colder climates, the tamarind which grows all over the country, as likewise the *Pithecellobium dulce* (jungle jalebi) with its small leaflets. Certain wild trees such as *Celtis australis, Holoptelea integrifolia* and many of the acacias are also excellent bonsai subjects though not so easily available in nurseries because they are not used as shade or decorative trees. Many more trees are available to the bonsai grower besides those listed above.

Malpighia coccigera is an extremely attractive shrub bearing small white or light pink flowers in many profuse flushes. The leaves are small neat and shining, like miniature holly leaves and the plant lends itself to shaping in many styles. The Chinese orange and miniature pomegranate both produce pretty flowers and the small proportionate, variegated *Duranta* and Chinese lime(*Triphasia trifolia*) are all useful shrubs for bonsai. The last mentioned develops a large number of small red fruit. *Murraya paniculata* and its more free-flowering varieties are also deservedly becoming popular.

The creeper of choice for the bonsai grower is the *Bougainvillea* where the choice of colour and style is great. It would be better not to choose a very rampantly growing variety as its control would be more difficult than one with a neat habit of growth like the small-leaved variety 'Sanderiana'. A visit to a *Bougainvillea*-growing nursery during the flowering season would help in the choice of colour and growth pattern. A favourite creeper in Japan is the *Wisteria* which can only be grown in cooler parts of this country but the *Petrea volubilis* is a fairly adequate replacement. *Banisteria laurifolia* with its elegant *Malpighia*-shaped, bright yellow flowers is a cheerful addition to the bonsai collection as also the white-flowering star jasmine (*Trachelospermum jasminoides*) and the honeysuckle (*Lonicera japonica*). The last mentioned is eminently suitable for the 'rock-clasping' and 'cascade' styles. Several herbaceous plants are also used in bonsai culture. Bamboo, *Nandina domestica, Crassula argentea* (jade plant) and

Fig. 2. *Bougainvillea* 'Sanderiana'.

forming it ultimately into a bonsai needs care and discrimination on the part of the buyer. An old plant naturally would have a desirably thicker trunk. The trunk would need examination to determine if it could be bent in any direction, alternately if without bending it would lend itself to shaping into the style to be made. It is always better to have a number of branches within 10–25 cm of the base of the trunk from which to choose the three main branches of the future bonsai.

Training. The health of the plant and freedom from pests is also to be assessed. Before potting the plant, a suitable style is to be decided on. Unnecessary branches are removed, the tip of the tree is chosen and the rest of the plant is cut off above this level. Copper wire is used to arrange the branches in the correct position and with any necessary curves. The wire used must be thick enough to hold the branch or trunk being wired in the position chosen, but not

thicker than desired. The length of wire is measured against the part to be wired and is cut off. For the trunk the wire is pushed into the soil at the back of the tree for about 4-5 cm and coiled round the trunk in evenly-spaced, firm, but not tight spirals to well above the last curve desired. When a branch is to be wired the beginning of the wire must be fixed over the fork, where the branch separates from the trunk, by passing a loop of wire firmly round it and then continuing the wiring as described for the trunk. The bending of either trunk or branches is to be carried out with extreme care placing the thumbs in the concave side of a curve to support it and prevent breakage. When the whole tree has been shaped with wire the branches and twigs are shortened if necessary in proportion with the height of the tree. Other methods of changing the position or direction of the branches may be also improvised by tying polythene tape to the branch and the pot or any other object. Wire has to be removed in approximately three months after application to avoid permanent disfiguration of the part wired, whereas tape may be left on for any length of time.

The next step is to prepare the container decided upon by covering the drainage holes with plastic netting and spreading a layer of soil over the bottom of the pot. The plant is taken out of its pot with the soil intact, and with a pointed stick (a No. 8 or 9 metal knitting needle is suitable). The soil, which should be fairly dry, is carefully removed from the outside of the ball of earth, inwards and downwards until about two-thirds of it has been removed. The tap root is then to be identified and if the fine fibrous roots are plentiful it should be completely removed. If the small roots are not sufficient to supply the tree with sustainence a portion of the tap root is cut off and the remainder left till the tree is re-potted. Any other thick roots may also be proportionately removed. The remaining fine roots are clipped back if too long and the plant is now positioned in its container. Soil is poured in around the tree to fill the pot and is poked under and around the remaining ball of earth with the pointed stick to eliminate air pockets and to firmly settle the tree. If air pockets are not filled carefully as described the fine roots will die off when they reach such a pocket and this inevitably endangers the safety of the tree. The ball of earth, if too large to fit into the depth of the pot, may project above the level of its top, but this may easily be covered over with soil. An uneven surface frequently looks natural and attractive. The top of the soil may be finished off with green moss which is thinly removed from the damp shady places where it grows and placed on the soil surface, being careful to press the edges firmly onto the soil to prevent them from curling up and drying. A tastefully chosen and positioned rock may add to the aesthetic appearance of the tree. Watering is now carried out by placing the planted tree in a basin of water which reaches within 1 cm of the top of the pot. The water will pass through the drainage holes and the bonsai may be removed from the water when all the soil is soaked. The bonsai is now to be kept outside in such a place that it is shaded from the sun and sheltered

from wind.

Aftercare. Many people feel that once they have started a bonsai or been given or bought one nothing further is to be learnt. This is far from the truth because the correct care of the bonsai is what leads to its healthy growth. The bonsai needs fresh air and sunshine, food and water, pruning and pinching, removal of weeds and dealing with pests and diseases besides repotting when necessary. The bonsai is an outdoor plant and depending on the species, needs its full share of sunshine. Morning sun for a few hours will suffice but most bonsai prefer sunshine for a greater part of the day if they are shaded between the hours of 12 a.m. and 4 p.m. in summer. If sunshine is only available from one direction the bonsai must be turned round once a week to avoid lopsided growth.

Irrigation. The art of correct watering has to be learnt by the owner of the bonsai. Water has to be given when the top-soil begins to dry and if given from above by the use of a spray attachment to a water-pipe or from a watering-can it must be given in such quantity that excess comes out through the drainage holes. A few bonsai may be watered by the method used in the first potting of a bonsai but for a larger number this would become cumbersome. A few points about the watering of bonsai deserve special mention. It is the wind more than the sun that dries the plant whether it is cold or hot wind, therefore greater care in watering is needed on windy days. Plants, like pines, which use less water need watering less often than broad leaf trees, but when watered some water should flow out of the drainage holes otherwise the bottom roots will suffer from drought which may ultimately kill the plant. Dormant plants need water but much less frequently than when not dormant. During rainy weather a shower may have been insufficient to completely water the bonsai and in such cases water should be supplied as usual. Plants which are due to produce flower buds benefit by less frequent watering. It is better not to water during the mid-day hours of summer or at least it should be seen that water does not fall on the leaves at this time of the day.

Nutrition. Some of the safe fertilizers to use on bonsai are the various oilcakes like rapeseed cake or *neem* cake. The method of using them is to soak the oilcake in the proportion of 1 kg per ten litres of water in a well covered vessel until fermentation has taken place which is in approximately two to four weeks depending on the season. The liquid is then used diluted one in fifteen with water, on plants which have been watered a short while before. This may be used once a week in about a month after potting or repotting when the roots are growing well. The periods in which to avoid the use of fertilizers are during the monsoon and the tree's dormant season. Alternatively a good mixed NPK fertilizer can be used though very sparingly. Superphosphates may be applied to encourage flowering as also bone-meal which may be added to the compost while potting or repotting.

Pruning and pinching. These are the techniques used to shape the tree and to reduce the size of the leaves. After the new growth has developed to four or five new leaves, the twig is pinched off just beyond the first or second leaf depending on which way the leaf behind the cut is pointing. This leaf is chosen to indicate the future growth of the new twig as it will grow in the same direction as this leaf. Repeated pinching in this manner is carried out through the growing season. Pruning is done when the tree is first planted and is repeated whenever found necessary to retain or improve the shape of the tree.

Daily care of the bonsai includes removing weeds, unnecessary new buds, and dealing with pests and diseases as they would be dealt with in the trees growing in the ground.

Repotting. Repotting of the bonsai is done once a year at the same time as the trees are normally potted, that is when they are budding. As a bonsai grows older, the repotting process needs to be performed once in two, three or more years depending on the age of the tree. To find if the tree needs repotting see if roots are protruding from the drainage holes and if much resistance is met to a finger or thumb pressed on the surface of the soil. This denotes the presence of very little soil and a large number of roots. These two points besides the sudden need of the bonsai for excessive water without much change in weather are indications that it needs repotting. The bonsai with the soil intact is taken out of the container which is washed, dried and prepared with plastic netting over the drainage holes and a layer of soil covering the bottom. Starting from the outer edge and proceeding inwards and downwards, the soil is removed from between the fine roots till it is approximately one-third of its original quantity and the fine roots are exposed. These roots are clipped back almost to the remaining ball of earth and also from its lower surface. Any thick roots that have grown are cut off. Fresh compost is added as described from potting and the bonsai is watered.

It will hopefully be clear from this description that to develop a bonsai simple horticultural techniques are used. The tap-root and other large roots are cut off to encourage the growth of fine fibrous roots. This is done when the buds are beginning to swell and the clipping of the roots stimulates the buds to grow and the growth of the buds in turn stimulates the roots to grow. Besides, the development and retention of shape and size of the bonsai is accomplished by pruning, pinching and wiring.

12

Propagation of Ornamental Plants

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PROPAGATION is an important aspect in ornamental horticulture. In nature plants multiply themselves by means of seeds and different vegetative parts. In the garden a horticulturist or a gardener has to learn the different methods of propagation by which the plants are multiplied, either to replace an old or diseased stock or to meet the increasing demands of an expanding garden or nursery. Broadly, the different methods of propagation are divided into 2 categories: (a) Sexual propagation and (b) Asexual or vegetative propagation.

SEXUAL PROPAGATION

Plants are sexually propagated by seeds and spores. However, a spore is basically an asexual body; but when it falls on a moist surface, it produces small plant bodies (prothallia), which develops the sex organs (archegonia and antheridia). These two organs in due course of time develop the sex elements (gametes), which fuse and the resulting body develops into a plant. This type of propagation is common in ferns.

In India sexual propagation is followed mostly in the cases of flowering annuals (seasonal flowers) and most of the shade, flowering or ornamental trees. Some annual creepers, like *Clitoria ternatea, Cobaea scandens, Lathyrus odoratus, Ipomoea* spp., *Quamoclit pennata, Thunbergia alata, Tropaeolum majus* etc., are also cultivated from seeds (Randhawa and Mukhopadhyay, 1986). The other type of plants which are also commonly propagated in our country from seeds are palms and different cacti and succulents. It is the commercial nurseries in India which propagate these plants from seeds.

Several ornamental shrubs like *Adenium obesum, Asclepias curassavica, Bauhinia acuminata, B. galpinii, Caesalpinia pulcherrima, Cassia biflora, Cotoneaster, Galphimia gracilis, Holmskioldia sanguinea, Memecylon edule, Nyctanthes arbor-tristis, Ochna squarrosa, Rauwolfia canescens, Sophora tomentosa* and *Thevetia neriifolia* are also propagated from seeds. While

some of the above shrubs are normally multiplited by seeds only (eg. *Cassia biflora*), but others can both be multiplied by seeds as well as other vegetative means (eg. *Adenium obesum*). Besides, some shrubs which are normally used as hedge in the garden are also multiplied by seeds. These are *Lawsonia alba, Malpighia coccigera, M. glabra* and *Murraya exotica.* It may be noted that some of these can also be propagated by one of the vegetative methods.

Several other ornamentals, which are not normally propagated from seeds by horticulturists in the garden, are multiplied by seeds by breeders to get new hybrids. Some of these plants are rose, chrysanthemum, gladiolus, hippeastrum, bougainvillea, hibiscus, crotons etc.

Some seeds which have hard seed coats need external treatments to facilitate quick as well as better germination. The methods employed are cracking or chipping of seed coats by mechanical means, abrasion, soaking in water, scarification (in acid) and stratification. Mechanical scarification of sandal seeds reported to have improved their germination (Rao and Reddy, 1980). Removal of the mesocarp (hard shell) in sandal seed also accelerated germination (Srimathi and Rao, 1969). Seeds of many tree species (e.g., *Mimusops elengi, Delonix regia*) need pre-soaking in water for about 24 hours for better germination. A corner of these seeds could also be chipped (or cut) carefully, before sowing for better penetration of water. Seeds of other plants like palms, canna and rose also have hard seed coats and need pre-treatment before sowing. In rose, to obtain good germination the seeds are subjected to cold treatment before stratification. To improve the germination percentage of rose seeds, a procedure had been developed at the Indian Institute of Horticultural Research (Alexander, 1977), which may be described. After the rose hips (i.e. fruit) ripe and turn pink, these are harvested and dried for 2–3 days. The seeds are extracted from the hips and immersed in concentrated sulphuric acid for 30 minutes and then washed in running water for about a couple of hours. This procedure is known as scarification. After scar fication, the seeds are mixed with fine sand or vermiculite and transferred into a plastic bag, whose mouth is sealed after the proper identification levels are put inside. The packets are then placed in a refrigerator at 3°C for 3 months. Thereafter, these are sown. Some improvement in germination was reported following this treatment.

It has been observed that treatment with various growth regulators improved seed-set in many ornamentals. Thus Bose and Kapur (1969) observed that GA_3 spray at 1 ppm, 24 hours after pollinat on increased percentage of seed-set. Similarly, Bose and Mukherjee (1968) noted that application of GA_3, IBA, and Naphlnalene acetamide (NAd) spray at concentrations of 1, 10 and 100 ppm after 6, 24 and 48 hours of pollination, improved seed-yield in cineraria. An earlier work (Rao and Rao, 1963) also showed the effects of gibberellic acid on fruit

development in *Hibiscus rosa-sinensis.*

The effects of pre-sowing treatment of seeds with growth regulators on growth, flower ng and seed-yield had also been studied on some ornamentals. Agnihotri and Srivatsava (1964) reported that when seeds of *Impatiens balsamina* were soaked in 5 ppm IBA solution before sowing for 20 hours, the resultant plants produced more seeds over the control. The work of Bankar (1980) on the effects of pre-sowing soaking of chrysanthemum *(Chrysanthemum indicum* L.) seeds with gibberellic acid indicated that plants produced from gibberellic acid-treated seeds (80 ppm) flowered early. Several other parameters were also affected. Rao and Reddy (1980) studied the effect of pre-soaking of sandal seeds (*Santalum album* L.) on germination. According to them higher concentrations of these chemicals accelerated germination. Venkatarayappa *et al.* (1982) studied that treatment of seeds of *Chrysalidocarpus lutescens* (a palm) with 50 ppm sodium cyanide and 50 ppm GA_3 resulted in early and higher percentage of germination with vigorous seedlings. Mulick and Chatterjee (1967) and Ravel and Chatterji (1971) studied the beneficial effects of sodium cyanide on germinat on in other ornamentals.

Climatic factors and nutritional status of the soil affect seed production in many ornamental flowers, especially the flowering annuals. According to Bose (1984) transplanting of China aster seedlings during first week of October, in West Bengal improved seed-yield. Whereas, early (September) or late planting affected seed-yield adversely. Similarly, planting of China aster during October in Pune, significantly produced highest yield of seeds (Anon., 1981). Marked difference in yield of seeds was noticed in *Tagetes erecta* (African marigold) in West Bengal due to variation in time of planting (Bose, 1984). Research conducted in Pune (Mahatma Phule Krishi Vishwa Vidyalaya) also indicated that time of planting had a bearing on the seed-yield of this crop. According to Bose (1984) carnations yielded higher quantities of seeds, when sown during October in West Bengal. Das *et al.* (1981) also observed the effect of environment on the seed-yield of *Echium plantagineum.*

Both nitrogen as well as phosphorus appears to have influenced seed yields in marigold, China aster and carnation. Yadav (1982) reported that application of 300 kg of nitrogen and 200 kg each of phosphorus and potassium improved seed-yield in African marigold. While Bose (1984) reported improved seed-yield in China aster as a consequence of application of 300 kg/ha of nitrogen; Yadav (1982) concluded that seed-yield of this crop could also be improved over control with the application of 200 kg/ha each of phosphorus and potassium. The s gnificant effects of increased seed-yield as a consequence of N (200 kg/ha) and phosphorus (400 kg/ha) application on China aster was also studied at Pune (Anon., 1981). Improved seed-yield as a consequence of mineral nutrition was also noticed in carnation (Bose, 1984).

Amongst some other factors which affect seed production in various ornamentals, self and cross incompatibility are also important. It is reported (Karihaloo, 1986, personal communication) that crop like tuberose cv 'Single' and some cultivars of *Hamerocallis* are self incompatible.

Another important stride made in India in the field of seed propagation is the cryo-preservation of seeds (i.e., preservation in liquid nitrogen), as a result of which the seeds remain viable for years together. A gene bank facility has been created at the Indian Institute of Horticultural Research, Bangalore, which is one of the only few such facilities in the world. Here seeds will be preserved for up to 20 years, without loss of viability, at a temperature up to –40°C. Thereafter, the seeds could be sown again and from the resultant plant a new generation of seeds will again be stored in the gene bank and thus the progeny will be perpetuated.

VEGETATIVE PROPAGATION

Vegetative propagation may be defined as a method in which a complete plant is produced from one vegetative bud or several such buds. This broad definition will include all asexual methods such as cutting, layering, division, separation, budding and grafting. A large number of ornamental plants, are multiplied by the one method or other of vegetative propagation.

Cutting

Cutting is a process by which a plant is produced by severing a vegetative portion from the plant and rooting it in a favourable medium under optimum conditions. Various plant parts such as stems, roots, leaves and modified stems such as corms, rhizomes, tubers, bulbs and runners, are used for this purpose. Raising plants by cuttings is the cheapest and most convenient method of vegetative propagation and is also the most popular amongst the gardeners.

The stem cuttings can be categorised into 3 types:

Soft-wood cuttings. These types of cuttings can still be sub-divided into two groups. In the first group comes those cuttings which are taken from herbaceous plants such as coleus, carnation, dahlia, chrysanthemum etc. The second group consists of cuttings taken from the unripened tips of woody plants, such as most of the ornamental shrubs and some trees. The cuttings should be detached from the mother plant from below a node.

Semi-hard-wood cuttings. Semi-hard-wood cuttings are those which have passed the soft-wood stage but yet to ripen fully. Jasmines and hydrangeas are example of plants from which such cuttings are taken for propagation.

Hard-wood cuttings. The cuttings which are taken from the mature current

years growth, as in some shrubs and trees. While in the first two categories of cuttings the length of cutting remains between 2.5 to 10 cm and 15 to 25 cm, but in case of hard-wood cuttings the length depends upon the nature of plants and prevailing climatic conditions. In trees like *Gliricidia maculata, Ficus benghalensis, Citharexylon* and certain *Erythrina* sp., 1- $1\frac{1}{2}$ m long cuttings root easily when planted in warm humid weather (Randhawa and Mukhopadhyay, 1986). But normally, for many other hard-wood cuttings the length varies between 15 and 30 cm.

The stem cuttings are further categorised into 3 groups:

(i) *Terminal cuttings.* Such cuttings are obtained from terminal portion of a shoot. The leaves from the lower portion of the cuttings are removed by snipping (and not by tearing off), while 2–4 leaves are retained in the apex. If the size of the leaves is very large, these may be cut into halves. Most of the cuttings are to be inserted in the rooting media as early as possible, after being detached from the mother plant. But in case of cacti and some other succulent plants, these are air-dried for 2–4 days before inserting in the rooting media (Das and Mukhopadhyay, 1976: Randhawa and Mukhopadhyay, 1986).

(ii) *Heel cuttings.* When lateral shoots are pulled off from the stem with a portion of the stem attached to it, these are called heel cuttings. Heel cuttings root more easily. If needed, the basal end could be smoothened off with a sharp knife. Sometimes carnation cuttings are taken in this way.

(iii) *Node cuttings.* Plants like *Dracaena* and *Dieffenbachia* are propagated from single or multiple node cuttings. Such cuttings are normally placed horizontally on the rooting media.

It is important to note the end of the cutting, which is nearest to the root of the parent plant, should be inserted in the rooting media, as roots will develop from that end only. This phenomenon is known as polarity. If a cutting is put upside down, either it does not root, or when in some cases it roots, the roots are few and short-lived.

The success of rooting depends on several external and physiological factors. The external factors are season, light, temperature, photoperiod, humidity, rooting media and aeration. In our country the rainy season in the plains appears to be the best time for striking cuttings or taking layers. Just before detaching the cuttings from the mother plant, if the mother plant was receiving optimum photoperiod, then the cutting would have accumulated good amount of carbohydrates, which in turn would be helpful in root generation. Cuttings root poorly if placed in shade compared to a lighted place. The formation of callus may be helped by a cool temperature, but root growth is promoted by higher temperatures. Since a detached cutting

cannot draw enough water, a humid atmosphere in the cutting zone is helpful for root formation. A good aeration in the rooting zone is also helpful and hence choice of media for striking cutting is important (Bose and Mukherjee, 1972; Randhawa and Mukhopadhyay, 1986).

Amongst the physiological factors which have bearing on rootings are presence of leaf and active bud (vegetative) in the cutting, polarity, nutrient level and amount of auxin present in the cutting. Polarity and the presence of leaf on cutting had already been emphasised. The presence of active bud or leaf is essential as auxins are produced in the buds. Atleast in certain species, the presence of flower buds have antagonistic effect on rooting. Low levels of nitrogen, rather than high is beneficial for root formation. A complete absence of boron may result in the total failure in root formation.

There are three methods of application of auxins. The more orthodox method, which is not followed much now is the prolonged soaking for 24 hours at low concentrations of auxins (10–100 ppm). The advanced method is to dip the basal portion of the cutting in high concentrations of auxins (1,000 to 10,000 ppm) for 5 seconds to 2 minutes depending upon the nature of cutting. In the third method, cuttings are treated with talc mixed with 500–12,000 ppm of auxins. The commonly used root-promoting auxin is Indolebutyric acid (IBA). Next in order of importance are Naphthaleneacetic acid (NAA) and Indoleacetic acid (IAA). However, the latter two are less uniformly effective. Sometimes a mixture of two hormones may be more effective. Bhujbal and Kale (1973) conducted a rooting experiment with *Rosa multiflora, R. bourboniana* and *R. moschata* involving the auxins IAA, IBA or combination of both. It was observed that *R. multiflora* produced the maximum percentage of rooted cuttings, and number and length of roots in response to 1,000 ppm of IAA+IBA. *R. moschata* also responded well to a combination of IAA and IBA treatment.

The relevance of rooting media has been mentioned earlier. A porous media which holds enough moisture (but at the same time drains excess water), and permits good aeration is congenial for root formation. Patil and Verma (1965) studied the effect of different media on the rooting of cuttings in *Hibiscus rosa-sinensis.* Hard-wood cuttings from this species were rooted in different media like sphagnum moss, shredded sphagnum, vermiculite, saw-dust, soil and sand. According to them the highest percentage of rooting was obtained in sphagnum (a highly porous media, which retains good moisture), followed by shreded sphagnum. The first-mentioned media also produced more number of roots.

The effect of season and photoperiod on rooting of cuttings has also been studied in some ornamentals like chrysanthemum (Shanmugam *et al.*, 1973). Chrysanthemum cuttings were subjected to 39 days supplementary

lighting from 6 p.m. to 6 a.m. starting either immediately after planting or 1 or 2 months later. The first two treatments increased the shoot/root ratio and the third treatment reduced it by enhancing root growth. According to Yadav *et al.* (1978), *Bougainvillea* cv. 'Mary Palmer' cuttings planted in middle of August produced highest percentage of rootings, average root numbers per cutting and maximum root length. Several other authors emphasised the importance of the rainy season for obtaining highest success in rooting of cuttings (Bose and Mukherjee, 1972; Randhawa and Mukhopadhyay, 1986).

The success of rooting in a cutting depends much on the juvenility of the cutting and presence of leaf or vegetative bud in the cutting. Cuttings taken from young plant, root easily, compared with those taken from an old plant (Bose and Mukherjee, 1972). Similarly cuttings taken from a recently matured wood will root better compared with those taken from old wood. The presence of leaf in the cutting for the promotion of root formation had been mentioned by many workers (Satpathy, 1961; Hore, 1962; Randhawa and Mukhopadhyay, 1986). Experimental evidences are available with several ornamentals in this regard. The presence of leaves in the cutting markedly promoted rooting and percentage of rooting as well as the number of roots per cutting, whereas leafless and budless cuttings failed to produce roots in plants like *Jasminum auriculatum, Hibiscus rosa-sinensis* (Mukhopadhyay and Bose, 1979) and *Bougainvillea* cv 'Mary Palmer' (Yadav *et al.*, 1978).

A survery through the literature on rooting of cuttings showed that a large number of works were concentrated on two plants, viz. *Hibiscus rosa-sinensis* and bougainvilleas. Some of the earlier works on *Bougainvillea* were carried out by Mukhopadhyay and Bose (1966), Rao (1967) and Srivastava (1966). While Mukhopadhyay and Bose (1966) and Rao (1967) used IBA, NAA and Seradix B-3 (a commercial hormone preparation) by the prolonged soaking method with weak concentrations, on the other hand Srivastava (1966) used both the soak and quick dip and talc methods with IAA and NAA using concentrations up to 20,000 ppm. He observed that prolonged soaking with IAA (50 ppm) or NAA (50 and 100 ppm)produced 100% rooting. Hundred per cent success was also obtained with quick dip at 8,000 ppm NAA. Not much of success was obtained with the dusting method with talc, but this treatment was better than the control. Mukhopadhyay and Bose (1966) concluded that the maximum success of rooting was obtained with IBA compared with NAA. Amongst the other workers who studied the rooting of cuttings with bougainvillea mention may be made of the works carried out by Bose and Bose (1968), Chakravarty (1970), Misra (1971), Nathulal *et al.* (1972), Mauraya *et al.* (1974), Yadav *et al.* (1978) and Mukhopadhyay and Bose (1979). In

a recent work Chaudhari *et al.* (1982) observed that *Bougainvillea* cv 'Shubhra' rooted well when treated with IAA, IBA or NAA at 150–750 ppm by quick-dip method. *Hibiscus rosa-sinensis* appears to be another popular plant on which several experiments on rooting of cuttings were undertaken. The effect of different growth regulators and their mode of application on softwood (Shanmugavelu, 1960), semi-hardwood (Shanmugavelu, 1960a) and hardwood (Shanmugavelu, 1961) cuttings of *Hibiscus rosa-sinensis* is discussed here. Seventy per cent success was obtained when the roots were soaked in IBA (25 ppm) and quick-dip treatment with IBA (2,000 ppm), while 75% success was obtained when the roots were given dust treatment with NAA (1,000 ppm). The semi-hardwood cuttings of the same plant responded well to produce 90% rooting with a 5 seconds quick-dip treatment either with IBA or NAA compared with 10% obtained with untreated cuttings. Prolonged soaking or dust treatment with either of the hormones produced intermediate responses. Hardwood cuttings were subjected to treatment with IBA, NAA or IAA. Maximum rooting success and length of roots were obtained by treatment with NAA, followed by IBA. The success obtained with IAA was comparatively less. The author concluded that for hardwood cuttings prolonged soaking was preferable to a quick dip or dusting. However, it may be mentioned here that now-a-days workers prefer a quick-dip method as this is less time-consuming and cumbersome. Moreover, it is said that in case of prolonged soaking some nutrients and possibly auxins leak out of the cuttings, which is detrimental for rooting. Mukhopadhyay and Bose (1979) emphasised the presence of leaves in *Hibiscus* cuttings for proper rooting.

Factors responsible for rooting in *Hibiscus* were studied by various workers. In an investigation vegetative twigs of a shy-rooting white-flowered variety were girdled at a distance of 20 cm from the tip and held on the mother plant for 10, 20, 30 and 40 days before cuttings were taken and planted. Rooting was poor and only 8% of the cuttings detached 30 or 40 days girdling produced roots. Analysis of amino acids from the cuttings indicated that alanine, arginine and glutamine were present in larger amounts 40 days after girdling and histidine 30 days after girdling. In the easy-to-root red variety concentrations of these four amino acids increased progressively after girdling. This investigation indicated the possible role of amino acids in rooting of cuttings. Choudhury and Gaur (1953) studied the beneficial effects of certain amino acids and growth regulators on the survival and rooting behaviour of *Duranta plumieri* cuttings. Further work had been done by Bose *et al.* (1973) on the physiology of rooting of easy-to-root and difficult-to-root cultivars of *Hibiscus rosa-sinensis* and *Bougainvillea.* They observed a significant decrease in auxin level during the course of root formation in the easy-to-root cuttings of *Bougainvillea* cv 'Partha' and *Hibiscus* cv 'My Beauty'. No significant auxin activity could be detected in the cuttings of the difficult-to-root materials

like *Bougainvillea* cv 'Formosa' and *Hibiscus* cv 'Sweet Heart', either initially or during root formation in the presence of or absence of IBA. Further they also noticed that in the easy-to-root materials the phenolics, like *p*-hydroxybenzoic acid, ferulic acid and *p*-coumaric acid, which are known synergists for promoting rooting, were present in appreciable quantities. In the difficult-to-root cultivars only *p*-hydroxybenzoic acid was present in high concentrations, and the other two phenolics were not present in detectable quantities. This finding may well explain why some cultivars root easily whereas others do not. Some other works on effects of auxin synergists on rooting may be quoted here. Many synergists when used in combination with auxins induce much more rooting than when the auxin is used singly. But treatment with a synergist only may not improve rooting. Basu *et al.* (1969) observed that tannic acid and gallic acid promoted rooting in leafy cuttings of *Eranthemum tricolor* in combination with IBA and NAA. Salicylic acid in combination with IAA, IBA and NAA greatly promoted rooting in the same species. Synergism was also noted between *p*-hydroxybenzoic acid and IAA or NAA. Results of similar nature were obtained by Bose *et al.* (1972). They observed that *p*-hydroxybenzoic acid and salicylic acid were effective synergists of IAA, IBA and NAA in forming roots in cuttings of a number of ornamental shrubs. In some cases gallic acid and tannic acid also showed synergistic effects with auxins. It will be interesting to quote here that Mitra *et al.* (1982) obtained marked promotion of rooting by using ethylene (from ethrel) and acetylene (from calcium carbide) in cuttings of *Tagetes patula* cv 'Red Brocade'. They inferred that ethylene proved more effective than acetylene. In an earlier work similar response of root formation was reported by Bose *et al.* (1977), using ethylene and acetylene in number of semi-woody and herbaceous plants.

Effects of growth regulators on the rooting of several other ornamental shrubs has been studied. One of the earliest work (Bajpai and Parmar, 1958) on rooting of cuttings with *Jasminum sambac* indicated that 0.04% IAA with hardwood cuttings and 0.02% NAA with semi-hardwood type, gave the highest percentage of success. It was found that the presence of leaves markedly promoted rooting in cuttings of *Jasminum auriculatum* (Mukhopadhyay and Bose, 1979). Bose *et al.* (1973) observed good success of rooting in *Jasminum* with IAA, NAA and IBA. Singh (1979) also studied the effect of rooting media and Indole-3-butyric acid on root formation in *Jasminum sambac* cv 'Motia' semi-hardwood cuttings under intermittent mist.

It is difficult to summarize all the works on rooting of cuttings undertaken in India. However, a short discussion on the cross section of works done on a number of ornamentals will give some insight into the trend of research on this aspect. *Lagerstroemia indica* and the hybrid *L. lancasteri* are two important and beautiful shrubs of India. They bear very attractive flowers. It is

reported that the latter shrub totally fail to produce roots from cuttings when planted outdoors and less successful under mist even if hormones and improved rooting media are used. A rooting experiment carried out with this hybrid showed that if ringing (or girdling) is carried out at different intervals (one, two and three weeks) before detaching the cuttings from mother plant and these are treated with 400 ppm IBA and rooted under mist, a 80% success on rooting was obtained with 90% survival of rooted cuttings (Gupta, 1982). Bose and Mukherjee (1968) also obtained good success with unringed one-year-old cuttings of *Lagerstroemia indica* when treated with commercial preparations of hormones (Seradix) and IBA or NAA under field conditions. Samantarai and Pattanaik (1952) obtained good success in rooting of stem cuttings of *Dracaena angustifolia* when treated with synthetic hormones

Poinsettia pulcherrima or the Christmas shrub is a most ornamental shrub when in bloom. The showy bracts are its main attraction. Though this plant is not so widely grown in India, but in the USA this is the most widely grown during Christmas and its a real commercial success. Narayan Gowda *et al.* (1982), reported that rooting of this shrub was improved by Indoleacetic acid, Indolebutyric acid and Naphthaleneacetic acid under intermittent mist. They concluded that IBA at 500 ppm and NAA and IAA at 400 ppm recorded maximum rooting. Another beautiful foliage plant belonging to Euphorbiaceae is the *Euphorbia caracasana* which is a difficult and slow-to-root species. In a rooting experiment (Swami Rao *et al.*, 1982) with shoot cuttings it was observed that percentage of rooting, root-length and number of roots per cutting increased with 5,000 ppm NAA followed by IBA and IAA. Reduction in length of roots was observed above 7,500 ppm in all the treatment.

Mussaenda philippica is an ornamental plant, which is commonly referred to as 'Double' Mussaenda because of the multi-whorled flowering bracts. It has several cultivars out of which 'Pink' and 'White' are very popular. These are normally propagated by air-layers, and hard-to-root with stem cuttings. One-year-old mature shoots of these cultivars were treated with different concentrations (0, 2,000, 4,000 and 6,000 ppm) of IBA or NAA and rooted under intermittent mist (Kumar and Vijay Kumar, 1984). The results showed that different concentrations of IBA and NAA promoted rooting in both the varieties. The effect of IBA was found to be more pronounced than NAA. Further the easy-to-root cv 'Pink' responded better to growth-regulator treatment. However, the percentage of rooting decreased with increase in the concentration of IBA and NAA. Shanmugavelu (1980) was successful in raising *Allamanda cathartica* from cuttings with the help of growth regulators. Tiwari *et al.* (1968) successfully raised cuttings of *Murraya exotica* by treating the cuttings with NAA.

In rose some work on rooting of cuttings, mostly with rootstocks, was undertaken. One significant step in the propagation of rose was the development of a 'Thornless' mutant which is used as a rootstock (Mukhopadhyay *et al.*, 1980). This rootstock roots with 90–100% success in the open without even being treated with hormones (Mukhopadhyay and Bankar, 1980). The other rootstocks with which the same authors succeeded in getting good rooting in the open without any hormonal treatment are *Rosa multiflora, R. indica* and 'Dr Huey'. But according to them *R. bourboniana* and *R. damascena* performed poorly in comparison under Bangalore conditions. The works of Bhujbal and Kale (1973) on rooting of cuttings of different rootstocks has been mentioned earlier. According to Das *et al.* (1978) different *Rosa* species behaved differently when treated with various root-promoting hormones. Thus *Rosa indica* var. *odorata* rooted best when treated with IAA at 1,000 ppm. Whereas *R. multiflora* responded well to treatment with 1,000 ppm IBA.

Not much research work was carried out to grow some modern rose hybrids (Hybrid Tea or Floribunda) on their own roots (i.e., raising the plants by stem-cutting or air-layering), rather than being budded. The first such work was carried out by Iyengar (1961) with basal cuttings and he obtained some success. Mukhopadhyay and Bankar (in press) treated cuttings of 'Happiness', 'Super Star' (both Hybrid Tea) and 'Queen Elizabeth' (Floribunda) with either 1,000 or 2,000 ppm IBA and planted them in mist. Only 'Queen Elizabeth' cuttings treated with 2,000 ppm IBA rooted well (88%) and rooted cuttings survived. These were put on a replicated trial with budded plants. The plants raised from cuttings were shorter in length with less branches compared with budded plants. However, the plants raised from cuttings flowered well and were found to be good enough for garden display purposes.

The use of intermittent mist for the propagation of stem cuttings has brought a revolutionary change in the field of propagation in ornamental horticulture in India. By using this method, now it is possible to propagate many difficult-to-root shrubs, creepers or trees which were so far being propagated by seeds or air-layers. The pioneering and extensive work on rooting of cuttings of 62 different types of trees, shrubs and creepers in mist were reported by Bose *et al.* (1970) and Bose (1972). They used apical leafy cuttings and treated the semi-hardwood cuttings with 3,000 ppm of IBA or NAA in talc and for hardwood cuttings 6,000 ppm of the hormones were used. There was a set of controls (no treatment with hormones). It was observed that IBA was more effective than NAA. They observed that in 25 species there was no rooting in the control. In 48 species 80–100% rootings were obtained with IBA or NAA. In another 13 species 50–80% rootings were obtained. Difficult-to-root cuttings of *Saraca indica* also rooted well. The work of Bose and Mandal (1972) on the

propagation of ornamentals under mist may also be mentioned here. The successful raising of stem cuttings of *Lagerstroemia lancasteri* under mist (Gupta, 1982) has already been discussed. Mukherjee *et al.* (1976) and Singh (1979) also obtained great success in propagating various ornamentals under mist.

The use of mist and root-promoting hormones had made it possible to raise some trees by cuttings. Bose *et al.* (1970) could successfully raise cuttings of *Saraca indica, Peltophorum ferrugineum, Thespesia populnea* etc., in mist when treated with hormones. Mishra and Majumdar (1982) obtained good successes in rooting of trees like *Spathodea campanulata, Plumeria alba* and *Lagerstroemia flos-reginae* when treated with two or three combinations of IAA, IBA or NAA. In some difficult-to-root tree or shrub species good success in rooting may be obtained if the would-be-cutting is girdled (ringed) for 2–4 weeks before being detached and the ringed portion is treated with high concentrations of a growth hormone (eg. IBA) dissolved in lanolin paste. Within about 3 weeks callusing will be observed, when the twig is detached and placed in mist chamber for rooting. At the IIHR good success was obtained in rooting of *Delonix regia (gulmohar)* cuttings by this method using IBA at 8,000 to 12,000 ppm in lanolin paste. Surprisingly, Chaudhuri (1965) reported good rooting performance of cuttings of *Gliricidia* when treated w th 2,4–D (2, 4–d chlorophenoxyacetic acid). According to him treatment with 100 ppm solution produced the maximum roots and the hardwood cuttings responded better.

Samantrai (1955) obtained good rooting in ringed cuttings of *Magnolia grandiflora* when these were treated with the hormone NAA. Earlier in this article it has been mentioned that many trees root easily from cuttings without the aid of any root-promoting hormone or mist chamber.

There are some shrubs, herbaceous plants which can be propagated by root cuttings. Some of these are *Gypsophila, Gaillardia, Salvia, Aralia, Lagerstroemia* sp. etc. Many ornamentals like African violets (*Saintpaulia*), gloxinia, rex begonia, *Kalanchoe* etc., are easily propagated by leaf cuttings. The propagation of rex begonia by leaf cuttings had been described by Desai (1958) and Randhawa and Mukhopadhyay (1986). The procedures for taking leaf cuttings of African violet or *Kalanchoe* had been dealt with by Randhawa and Mukhopadhyay (1986). Another method of propagation by cutting is the 'leaf-bud cuttings' in which many ornamentals like hydrangea, geranium and camellias are propagated (Randhawa and Mukhopadhyay, 1986).

Layering

The next most commonly used method of propagation is layering. The plants which are difficult to multiply by cuttings can be raised by one or the other method of layerage with or without the help of growth hormones. Since the twigs still remain attached with the mother plant, so the supply of food and water is not

hampered. As a result the chances of rooting in layerage is better than in cuttings. Simple or ground layering is the simplest form of layering. Many of the variegated plants which do not root easily from cuttings like *Bougainvillea* cv 'Thimma' or *Duranta plumieri variegata* could be rooted by this method of layering. Some climbers are also rooted by this method.

Air-layering or *gootie* is one of the most widely used method of layerage in ornamental plants. A large number of shrubs, foliage plants and even trees are raised by this method (Randhawa and Mukhopadhyay, 1986).

There are some research findings on rooting of air-layers of some ornamentals. *Amherstia nobilis* is one of the most beautiful ornamental tree, which is difficult to propagate by vegetative methods. Bhandary (1962) studied the effect of some hormones on the rootings of air layers of this beautiful tree. Bose (1964) noted marked improvement in rooting in air-layers of *Amherstia* by application of growth substances. Nalwadi *et al.* (1982) obtained better rooting in layers of *Callistemon* when treated with a mixture of IBA and NAA rather than treating with IBA or 2,4-D alone. The rooting performances of several shrubs were studied by various workers. It was observed that *gooties* of *Carissa carandas* rooted well when treated with 7,500 ppm, IBA + NAA mixture in equal parts (Jauhari, 1960). Similarly *gooties* of *Althaea rosea* (hollyhock) rooted well when these were treated with IBA or NAA at 2,000 to 4,000 ppm individually or in combinations. Hulmani *et al.* (1968) recorded good success in layers of *Dracaena rosea ferrea* L. when these were treated with IBA and NAA in equal concentration of 20,000 ppm. Mitra *et al.* (1980) reported that when air-layers of *Gardenia florida* L. were treated with IBA and NAA in lanolin paste at 50, 100 and 150 ppm, all treatments including control produced roots. However, 100% rooting were obtained with the treatment of IBA and NAA at 50 ppm each.

According to Randhawa and Mukhopadhyay (1986) certain ornamentals like *Deutzia* sp. and *Cestrum nocturnum* can be raised by mount or stool layering.

In India *Chrysanthemum* is normally propagated either by suckers or cuttings. However, Mukhopadhyay and Das (1976) observed that atleast certain cultivars can be propagated by air-layers. It was concluded that propagation by air-layers shortened growing period and layers produced better flowers compared to cuttings. This method may be followed atleast for exhibition purposes.

Grafting and Budding

In ornamental horticulture grafting is followed only for few crops like cactus and in some other rare cases, where some species cannot be propagated by other means or they do not perform well on their own root. Budding is a form of grafting and is mainly followed to propagate rose.

In the nurseries around Bangalore, the ornamental tree *Michelia champaka* is universally grafted on *Michelia* rootstocks. Generally, the method of approch

grafting is followed. In eastern India around Calcutta, sometimes the delicate and rare shrub *Allamanda violacea*, which does not perform well on its own root, is approach-grafted on *A. cathartica* var. *schottii*. Similarly the shrub *Petrea arborea* which is difficult to propagate by other methods is grafted on *P. volubilis*. In West Bengal and Bihar, sometimes rose is propagated by approach grafting.

The other two methods of grafting followed mainly for propagation of cacti are 'Flat' and 'Cleft' grafting. There are some cacti (eg. *Gymnocalycium mihanovichii* cv 'Rubrum') which lack chlorophyll and hence has to be grafted on a green rootstock. Some delicate species like *Espostoa plumosa cristate* and *Cephalocereus senilis cristate* do not perform well on their own root and have to be grafted. Moreover, many cacti flower better (e.g. *Lobivia famatimensis*) when grafted. Then there are some trailing type of cacti, like *Aporacactus flagelliformis, Chamaecereus silvestrii* etc., which when grafted on a high rootstock, form into half standards and look nice. The commonly used rootstocks are *Trichocereus tephracanthus, Myrtillocactus geometrizans, Cephalocereus palmeri, C. albispinus* etc. Das and Mukhopadhyay (1976) had done some elaborate work on rootstock-scion relationship in cacti.

Some of the delicate Hawaiian *Hibiscus* cultivars are propagated by approach grafting or budding as this gives better results. Sharma (1962) suggested propagation of *Hibiscus* by grafting on a vigorous and hardy rootstock. The cultivar 'Alipore Beauty' may well suit for this purpose.

In India roses are normally budded by 'T' or 'Shield' budding. Maiti (1974) compared the methods of chip-budding and T-budding. According to him the method of budding had no effect on plant growth. Nanjan and Kumar (1982) compared patch-budding and shield-budding in rose and observed that it is possible to bud more plants at a given time by the patch budding method. The methods of buddings were described by Nanjan *et al.* (1971) in an earlier work. Maharana and Singh (1978) observed better bud union in direct sunlight than in shade or dark.

Effect of rootstock on the growth of scion had also been studied. It is common knowledge that in the north the usually used rootstock is *Rosa bourboniana*. But now-a-days the rootstock *R. indica* var. *odorata* is more commonly used there. In the south and eastern India, *R. multiflora* is more commonly used as a rootstock. The newly developed 'Thornless' rootstock (Mukhopadhyay *et al.*, 1980) is becoming quite popular in Bangalore and elsewhere. According to Swarup and Malik (1974) *Rosa indica* var. *odorata* is performing as a better rootstock compared to *R. bourboniana* or *R. multiflora* in the north. But Mukhopadhyay and Bankar (1982) observed that *R. multiflora* is a better rootstock for the south. According to the latest observations of these workers, the 'Thornless' rootstock is performing well.

The method of bench-grafting in roses is now being advocated (Gill, 1984)

for faster multiplication. In this method, the scion cultivar is first budded on the cutting of the rootstock and then these are rooted in the propagation bed. Mukhopadhyay (1985) also advocated bench-grafting in roses for fast multiplication.

Propagation of Bulbous Plants

The word 'bulb' in commercial horticulture means much more than the strict botanical interpretation. Besides bulbs, this includes rhizomes, corms and tubers.

The important plants which are propagated by bulbs are *Hippeastrum*, tuberose, *Hemerocallis*, football lily etc. Plants like tuberose and *Hippeastrum* produce both bulbs and bulblets (small bulbs), and both are used for multiplication. Similarly plants like gladiolus produce corms and cormels (small corms) and both are used for propagation. However, bulblets or cormels do not flower in the first year of planting. There are several enviornmental and physiological factors which influence the production of a bulb or corm. Temperature and photoperiod influence cormel production in gladious. Research conducted at the IIHR indicated that bulb production in tuberose (Mukhopadhyay and Bankar, 1981) and corm production in gladiolus (Bankar and Mukhopadhyay, 1980) is affected by time of planting.

The other factors which influence corm or bulb growth are the size of transplant planted, spacing (or plant density), and the depth of planting and nutrition. Most of the works in India on these aspects are on tuberose and gladious. In gladiolus, large-size corms when planted 5 cm deep with a spacing of 10 cm × 30 cm produced maximum number of corms and cormels (Bose, 1984). Though Bankar and Mukhopadhyay (1980) did not find any effect of corm size in gladiolus on corm or cormel production but they observed high density of planting adversely affected cormel yield, while shallow depth of planting of corm improved cormel yield. The beneficial effect of large bulb size, wider spacing and shallow depth of planting had also been studied in tuberose by Sadhu and Das (1978), Bhattacharjee *et al.* (1979), Mukhopadhyay (1981) and Yadav *et al.* (1983).

Nutrition also improved bulb-yield in bulbous plants. The effect of nitrogen appears to be important in this regard. Bose (1984) observed that in gladiolus a balanced dose of N, P and K improved corm and cormel yield. Under the All-India Co-ordinated Floriculture Improvement Project (Anon.,1983–84) research conducted at Delhi and Bangalore indicated the role of nitrogen and phosphorus in increasing corm and cormel yields in gladiolus. Bhattacharjee (1981) also observed increased cormel-yield with nitrogen nutrition. The influence of nitrogen in improving bulblet-yield in tuberose was studied by Jana *et al.* (1974), Mukhopadhyay (1981) and Yadav *et el.* (1983).

The role of growth regulators on the yield of bulbs or corms was also studied.

Soaking of corms with gibberellic acid improved cormel yield in certain cultivars of gladiolus (Bhattacharjee, 1984; Dua *et al.*, 1984), while in others no significant effect was observed (Mukhopadhyay and Bankar, in press). The effect of soaking gladiolus corm in Ethrel (50–1,000 ppm) improved cormel y eld (Mukhopadhyay and Bankar, 1981), while in tuberose opposite results were observed with spray application of GA_3 or Ethrel (Mukhopadhyay and Bankar, 1983). Moreover, the work of Mukhopadhyay (1981) also confirmed that soaking of tuberose bulb with GA_3 reduced the number of bulbs produced. Improvement in cormel production as a result of soaking of corm with IAA was reported by Bhattacharjee (1984).

TISSUE CULTURE

Bajaj *et al.* (1983) was successful in obtaining complete plants of gladiolus from the *in vitro*-cultured cormels, cormel tips and axillary buds. They were able to multiply 6 plants from the segment of one cormel, whereas in nature only one plant was obtained per cormel. The works on micro-propagation of gladiolus, rose and bougainvillea are also going on at the IIHR, Bangalore, and elsewhere.

CONCLUSIONS

Although good amount of work has been done in the past in the field of propagation of ornamentals, much more remains to be done. Efforts should be made to propagate some of our beautiful flowering trees, which are difficult to propagate (e.g. *Gustavia*), by some vegetative propagation methods or tissue culture. Mass propagation of many ornamentals should be taken up by tissue culture as is done in the USA. It is heartening to note that the National Horticulture Board is planning to mass-propagate rose by tissue culture. Anther culture and protoplast fusion techniques should also be perfected.

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13

Physiology of Ornamental Flowers

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MAN has selected flowers for their beauty, hues, shapes, scent and keeping-quality. Flowers have become symbolic of his sentiments and an essential part of his religious and social ceremonies. In India, flowers are generally cut without stalk and used fresh. Wreaths of jasmine, marigold, crossandra, tuberose, rose and champak are offered in temples and also used for personal adornment. Our knowledge of the physiology of senescence of flowers grown in India is meagre. It is only recently that floral decorations as practised in the developed countries have gained popularity in our country. Urbanization, tourism and trade have been mainly responsible for the increasing demand for cut flowers in hotels, conference halls, offices and homes.

With its varied agro-climatic conditions and relatively low cost of production, India has immense opportunities not only to meet the local demands of both traditional and vase flowers but also a high potential for export trade. Several attempts have been made sporadically to establish an export flower market. Lack of enterprise, technical know-how, standardized methods of growing and harvesting flowers of internationally acceptable quality, problems of packing and transport and a practically non-existent production base have been major impediments in realizing this goal.

Improvement in the quality of blooms has necessitated research into the basic and applied aspects of flower physiology in some of the major international centres of flower production such as Netherlands, the UK, the USA and Israel. Even in the developing countries such as Brazil, Columbia, Kenya, Thailand and Singapore export of flowers has assumed an important place in their economy.

There is a resurgence of interest in India to broaden the technical base and enthuse enterpreneurs to take up export of flowers. Research in several aspects of flower initiation, flower-bud development and opening, sex

expression, pollination biology and physiology of senescence in a large number of plants, especially ornamentals, has been carried out for the past two decades in this Department. In this paper, the main findings on flower-bud growth and on post-harvest physiology of flowers are summarized.

FLOWER-BUD GROWTH

Mechanism of Flower-Bud Growth in Gladiolus

A spike of gladiolus presents what may be termed nature's own flower arrangement. It is an ideal material for bud-opening studies. The occurrence of an acropetal sequence of stages of bud development on a single axis makes it possible to carry out several studies. The spike bears buds in two rows (distichous arrangement) with the telescoping of the outer bracts over one another. The elongation of the flowering axis between the buds loosens and separates the outer bract from the axis.

The fresh weight of the corolla increases 16 times, and the dry weight by seven times between the time the outer bract separates out until the corolla attains its full expansion (Rao, 1979; Bala, 1982). A machinery has to be built up and sustained in the corolla to support the large inflow of materials, since it is a non-photosynthetic organ. Thus spikes harvested one week before the first floral bud opens need exogenous supply of sugars for subsequent flower growth and opening (Rao and Mohan Ram, 1981). The growing corolla continues to import sugars throughout its development. Probably only a small proportion of the sugar is used metabolically. The function of sugar which is not directly involved in metabolism is unknown. A part of the accumulated sugar in the petals is secreted as nectar. In gladiolus, this occurs at anthesis (Rao, unpublished work).

The petals belonging to the buds with unseparated outer bracts were observed to contain abundant starch in the ground parenchyma only (Rao and Mohan Ram, 1980). With the separation of the outer bract from the axis, a gradual dissolution of starch starts in the tissues located at the tip of the petal. With increasing age of the bud, starch hydrolysis eventually reaches the base of the petal.

In gladiolus, α-amylase and acid invertase activities increase with the progression of corolla development and have a positive correlation with the amount of carbohydrates (Bala, 1982). The decline in starch in late developmental stages can be correlated with the sharp rise in α-amylase activity and reduc ng sugar content. It may be inferred that the reducing sugars being osmotically active cause an influx of water, resulting in turgescence of the expanded corolla (Rao and Mohan Ram, 1980).

In gladiolus, the system of overlapping outer bracts which completely

enclose the flower buds and their gradual separation represents a system programmed for sequential exposure of successive buds to light and stimulation of α-amylase, to permit an orderly development of buds. The outer bract acts as a natural qualitative light filter and regulates the production of α-amylase and petal growth by a red/far-red control (Rao, 1982; Rao and Mohan Ram, unpublished work). α-amylase is formed exclusively in the petal epidermis on perception of light. The enzyme is transported to the ground parenchyma where it hydrolyzes the extensive starch reserves (Rao and Mohan Ram, 1980). The production of α-amylase is also regulated by the sequential basipetal differentiation of the epidermal cells (Rao, 1982).

A crucial structural and biochemical role of the epidermis in the percept on of light leading to petal growth has been recognized. Rao (1979, 1982) has observed that the epidermal cells of petals of gladiolus possess microlenses. These are formed by the outward growth of the outer radial wall of the epidermal cells causing the formation of curved structures which are thicker in the middle than at the edges. These microlenses act to focus light specifically on to the nucleus which is situated in the central zone of the inner radial wall of the epidermal cells. The development of the microlens is characteristic of differentiated cells; undifferentiated cells have a flat surface. Importantly, it is only after the formation of the microlens that the epidermal cells become competent to be induced by light (Rao, 1982). These cells then start producing α-amylase which is transported to the ground parenchyma where hydrolysis of the accumulated starch takes place (Rao and Mohan Ram, 1980).

A critical stage in flower-bud growth in the spike of *Gladiolus* which is initiated by gibberellic acid and sustained by sucrose has also been identified (Rao and Mohan Ram, 1982a). This corresponds to the stage at which separation of the outer bract occurs, leading to the induction of α-amylase by light (Rao and Mohan Ram, 1980). Buds not induced by light respond more significantly to GA_3 and sucrose than those induced by light. Since the separation of the outer bract results in light-induced α-amylase production and starch hydrolysis leading to petal growth, it is inferred that growth promotion by GA_3 is related to light-induced petal growth at this specific stage (Rao amd Mohan Ram, 1982a). The demonstration in gladiolus (Rao, 1982) that the growth of petals at different developmental stages is a function of the levels of α-amylase in those stages strengthens the conclusion that sugars released through α-amylase activity are directly involved in petal growth. Light-mediated α-amylase production could thus be an important step in the formation of an active sink to draw materials from the rest of the plant. One important role of continued and sequential basipetal starch hydrolysis in the gladiolus petal (Rao and Mohan Ram, 1980) could be to maintain a constant osmotic as well as a sink potential in the growing area of the petal, in spite of water

uptake.

Growth of Capitulum in Chrysanthemum

Studies on cell and organ expansion have been mostly confined to vegetative parts. Information on cell expansion in floral organs is scanty. This may be traced to lack of good experimental systems rather than to absence of interest. As production of large and showy blossoms has been an important concern of florists, an understanding of the physiology of flower expansion would certainly merit serious study.

Chrysanthemum is only next to rose in importance as cut-flower in world trade. It comes in various sizes and shapes and has an unmatched wholesomeness and elegance. Pardha Saradhi (1985) had made a detailed study of the growth of *Chrysanthemum* capitula using different stages. His findings reveal that the fresh and dry weights of the ray florets increase until the capitulum is fully open. The soluble protein content declines after opening. Ray florets contain the highest amount of protein. Acid phosphatase activity is very high in the ray florets followed by that in the disc florets. The maximal activity of this enzyme and of acid invertase coincide with the period of highest increment in fresh and dry weights. Amylase activity increases in the florets till the half-open flower stage. Interestingly peroxidase activity registers a continuous enhancement with a major increment during senescence. Ethylene production is low during the initial stages of development of the capitulum and increases with age in all the components.

In most investigations on flower growth, emphasis has been on the growth of corolla as it generally constitutes the most conspicuous part of a flower and since the changes occurring in it are rather dramatic. An elegant method has been developed in this laboratory to study the expansion of ray florets. This consists of floating ray florets (9 to 9.5mm) of *Chrysanthemum morifolium* var. 'Jyotsna', removed from the outer-most whorl of young capitula in petri-plates containing 30 ml of the test solution (Pardha Saradhi and Mohan Ram, 1982). Using this technique it has been shown that KCl causes up to 33% increase in elongation. The values for GA_3 and sucrose when used individually are 39.8 and 28.9% respectively. Maximal growth response (82.8%) is recorded in KCl+GA_3 + sucrose. It is inferred that the increased turgor resulting from sucrose-promoted potassium uptake along with GA_3-caused tissue extensibility accounts for the enhanced floret growth.

N,N′-dicyclohexyl carbodiimide (DCCD), a potent inhibitor of membrane-bound ATPase strongly inhibits the growth of ray florets of *Chrysanthemum* even under *in vivo* conditions. Ray floret expansion is also retarded by (2-chloroethyl) trimethyl ammonium chloride (CCC), an inhibitor of gibberellin biosynthesis (Pardha Saradhi, 1985), implying that endogenous gibberellins are involved in ray

floret growth. The CCC effect can be overcome by simultaneous application of GA_3.

Role of Other Floral Organs in Corolla Expansion

By and large, the role played by other floral organs in petal expansion has been overlooked. Historically, the stamens were the first floral organs shown to influence corolla growth (Lang, 1961).

In gladiolus intact stamens promote the growth of isolated corollas. The increasing independence of the older stages of corolla on stamens in this plant suggests that the influence of stamens decreases as corolla growth advances, although it does not stop. The influence of stamens on corolla growth appears to be through the production of gibberellins since the critical effect of stamens can be completely replaced by GA_3 or GA_3 + sucrose. It appears that in an intact spike the gibberellin required for corolla growth is supplied by the stamens until the stage when separation of the outer bract occurs (Bala *et al.*, 1986). If, however, the harvested spikes are subjected to water stress the younger buds with unseparated outer bracts fail to open and show an obligate requirement for GA_3. This requirement has been shown to be a consequence of the sensitivity of the unseparated flower buds to water stress which causes a disruption in the endogenous gibberellin supply system from the stamens to the petals (Rao and Mohan Ram, 1986).

POST-HARVEST PHYSIOLOGY OF FLOWERS

Flowers age with time; they lose moisture and their colours fade. While flowers like jasmine and tuberose turn brown and dry, in some plants mass shedding of petals occurs. For instance, the petals of linseed and corolla of *Ruellia* drop within a few hours of pollination. The petals of gulmohar (*Delonix regia*) and amaltas (*Cassia fistula*) are shed more leisurely. Corolla abscision may be a rhythmic phenomenon in flowers such as *Nyctanthes arbor-tristis*. Although a majority of flowers are short-lived, there are orchids such as *Phalaenopsis shilleriana* in which a flower may stay fresh on the plant for as long as four months as it waits for the specific insect pollinator (Molisch, 1938). In most plants, the petals wither, the sepals drop and the stamens dry up following pollination.

A clear understanding of the causes of senescence should help in developing methods of harvesting, transporting and increasing the longevity of ornamental flowers.

Two factors which play a major role in regulating the vase-life of a cut flower are carbohydrate supply and water balance. Injury at the cut end or growth of micro-organisms in the lumen of xylem vessels (physical blockage) or accumulation of microbial secretions and/or metabolic by-products (physiological blockage) could prevent absorption, resulting in severe water

deficit. Cut-flower longevity is also curtailed by ethylene (Chandra and Mohan Ram, 1980).

Investigations on flowers such as roses, chrysanthemums, gladioli, carnations, snapdragons, lupines and narcissus have shown that addition of a respirable substrate such as sucrose, and antimicrobial agents such as streptomycin and 8-hydroxyquinoline citrate to the holding solution prolongs vase-life (Mohan Ram and Rao, 1977; Rao and Mohan Ram, 1982b).

Spikes of gladiolus are ordinarily harvested at the tight-bud stage when the corolla of the lowermost bud has elongated and is expected to open the following day. During long-distance transport, however, spikes of this stage are damaged considerably and their market value is reduced. If, however, the spikes are harvested in the bud condition (green-bud stage—harvested one day before the corolla of the lowermost bud has emerged from the enveloping bracts and the tip has just become visible) the disadvantage of damage to buds is overcome but only 50% of the buds open out. A pre-storage treatment of the bud-cut spikes with sucrose ensures good opening. As a post-storage treatment, however, sucrose is only partly effective and treatment with GA_3 along with sucrose causes opening of all the buds. The need for supplying sucrose to the green-bud spikes (as pre-or post-storage treatment) to ensure good opening as against the tight-bud spikes in which all the buds open in water appears to result mainly from lower carbohydrate reserves. Under field conditions it takes one week for the green-bud spike to attain the tight-bud stage. In this period the spike continuously accumulates carbohydrates. The presence of low amounts of sugars and starch in the green-bud spike as compared with the tight-bud spike supports this conclusion, when considered along with the finding that exogenous supply of sucrose to the green-bud spike causes a much larger number of flowers to open (Rao and Mohan Ram, 1981).

The flower buds in the tight-bud spike are nearly twice as heavy as those on the green-bud spike. Thus most of the growth (gain in fresh weight) between the green-bud and the tight-bud stages occurs in the flower buds. Much of the fresh weight gain in the spikes in sucrose solution is due to the flowers (Rao and Mohan Ram, 1981).

In the developed countries it has become a common practice to harvest flowers of commercial importance in bud condition for easy handling, minimal damage and reduction in freight charges. Whereas such bud-out flowers can be caused to open by placing them continuously in sugar solution, a pulse treatment is preferable since it precludes the need for any additional treatment by the customer (Rao and Mohan Ram, 1982c). Pulsing of freshly cut buds of chrysanthemums and gladioli with a sucrose solution of high concentration before shipment or storage has been shown to cause enhanced flower opening and longevity. A method of opening the buds after storage

is, however, important in places where the growers do not have adequate facilities or training to implement such a treatment and it is easier for the wholesaler or the retailer to provide it. In comparison with the pre-storage treatment, in which a pulse with sucrose is sufficient for achieving satisfactory opening, in the post-storage treatment the use of GA_3 along with sucrose has been found essential for obtaining full opening of the buds in the spikes of gladiolus. This has also been found effective for spikes kept in cold storage after harvest. In the spikes pulsed after storage, greater turgidity and larger size of the flowers was noted over spikes subject to continuous treatments due to higher solution uptake and a better balance between uptake and loss. The amount of sucrose taken up markedly influenced flower longevity. However, no effect on flower opening was noted. The longevity of spikes pulsed for 48 hr with sucrose and GA_3 exceeded that of intact spikes in the field by one day (Rao and Mohan Ram, 1982c).

Flowers on a gladiolus spike open and wither in flushes. Premature withering and sometimes stem-break occur in cut-spikes in which water uptake is impaired. The former was shown to be the result of internal competition for water in which owing to lowered water uptake through the cut end, the opening buds extracted water from the older flowers and promoted their withering. The process of blooming, however, is fairly independent of free water availability through the cut end, as the flowers are able to obtain water from the withering flowers. Stem-break may result from reduced uptake caused by vascular blockage and a strong water requirement by the newly opening flower buds. The latter not only draw out water from the older flowers and cause their withering, but also are able to extract water from the flowering axis and peduncle and cause stem collapse (Rao and Mohan Ram, 1982b).

In comparison to water, the availability of sucrose was found to be a major factor in promotion of bud opening because of the ability of the newly opening buds to draw water from the flowers. Water stress pronouncedly affects water uptake and fresh weight of the spike but not the percentage of flower buds opening. Water stress also does not curtail flower longevity at any given concentration of sucrose (Rao and Mohan Ram, 1982d).

The property of sucrose to act as an antidesiccant when supplied before storage, in addition to its metabolic role is still not clear. It appears, however, that sucrose may protect the internal system for supply of gibberellins from the stamens to the petals from water stress (Rao and Mohan Ram, 1986). Thus gladiolus spikes given a pulse-treatment with sucrose before dry storage, enable the buds to open satisfactorily on subsequent transfer to water. However, if the spikes are first stored dry and subjected to water stress, it becomes necessary to provide gibberellins in addition

to sucrose to ensure full opening (Rao and Mohan Ram, 1979; 1982c).

FLOWER SENESCENCE

Senescence of flowers is strongly promoted by ethylene. Ethylene-induced senescence of carnation flowers was reported as early as 1908 by Crocker and Knight. It prevents opening of young blossoms, causes closure of opened flowers and discolouration and fading of petals. Pollination also causes fading of flowers and it has been inferred that the senescence of the flower is triggered by pollen-auxin stimulated ethylene production (Burg and Dijkman, 1967). Being autocatalytic, ethylene once formed stimulates further production of ethylene. It may be inferred that the longevity of flowers can be enhanced by preventing ethylene biosynthesis, accumulation or activity.

Antiethylene compounds such as $CoCl_2$, $NiCl_2$ and $FeCl_2$ promote the vase-life and increase the size of the cut-capitula in chrysanthemum and marigold (Chandra *et al.*, 1981; Pardha Saradhi, 1985). Use of sucrose along with $CoCl_2$ or $NiCl_2$ causes a further increment in vase-life by 20–24 days as compared to 7–8 days in water.

A spray application of $CoCl_2$, $NiCl_2$ or $AgNO_3$ to potted plants bearing fully opened capitula of chrysanthemum was effective in delaying their senescence by 10–15 days (Pardha Saradhi, 1985). Whereas silver nitrate causes formation black spots on the florets, $CoCl_2$ does not impair the appearance of the blooms. Thus the life-span of cut as well as intact chrysanthemum capitula can be extended by using $CoCl_2$ or $NiCl_2$. This finding needs to be put to practical use.

CONCLUSIONS

The brief account of the work carried out by our research group at the Department of Botany, University of Delhi, has shown that experimenting with flowers is a rewarding, intellectual and an aesthetic experience. It is our hope that the enthusiasm with which we have studied the physiology of flowers would turn the horticulturists in need of this knowledge to solve practical problems of flower-growing and trade. We also recognized the need to understand the science behind empirical indigenous practices of growing, harvesting and storage of native flowers to put it on a sound basis for exporting oriental flowers to the rest of the world.

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DEDICATION

A flower bud opens, displays its splendour and withers away in due course. We watch these events with wonderment day after day and season after season. Yet, when we try to understand the basis of flower growth and wish to develop techniques to prolong the life of harvested flowers, we find little information available in India based on experimentation and systematic analysis. We have summarized our findings of experimenting with flowers and offer it to Dr B.P. Pal as a tribute to his deep interest, knowledge and love of flowers.

Much of the inspiration for doing this work, has come from Dr Pal, who teaches by example. Our joy in including this work in the volume to be presented to him has become greater by the fact that our Guru, Professor Panchanan Maheshwari was a close friend of Dr Pal and they have both played a monumental role in promoting the growth of plant sciences in India.

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14

Essential Oils From Ornamentals

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ALL higher plants have some kind of aroma or flavour in their various parts, which include roots, stems, leaves, flowers and fruits. The flavour and aroma in a particular plant part is due to the presence of essential oils present in special glands in it.

Although all ornamental plants, specially those which have scented flowers or leaves, have essential oils, only a few of them are used commercially in perfumes, flavour or cosmetic industries. The number of plants having sweet-smelling flowers is more than a thousand. However, an attempt has been made here to discuss only those plants which have considerable commercial importance.

Essential oil from roses. In all the perfumes used in the world today, oil of rose is one of the costliest and the best known perfumery raw materials used by human beings for thousands of years. The first recorded reference of rose perfume is in *Charaka Sanghita.* However, rose water and rose perfume were probably known in the Indian sub-continent prior to Vedic Civilization. Results of archaeological excavations in Mohenjodaro and Harappa indicate that probably rose water and rose oil were distilled by the people of Indus Valley Civilization more than five thousand years ago. An intact terracota equipment for distillation of floral waters has been recovered during the excavations, which is kept in Taxila Museum, Pakistan. According to a romantic account, which is based on a book written by Mohd. Achem of King Jehangir's regime, the credit for discovery of rose perfume was given to Queen Nur Jehan. According to this account, canals of the palace garden were filled with rose water on the occasion of the royal wedding when Queen Nur Jehan noticed some drops of oil floating on the surface of water. She got it collected and gave it the name 'Attre Jehangiri'. However, this story even if it is correct, does not seem to be the first record of discovery of rose oil.

According to the Ibne Khal Doon, a well-established industry for production

of rose water was existing in Persia during A.D. 800-900 and Iran was the centre for production of rose water apparently during A.D. 1600 Rose water was a common item of trade between Iran, India, Spain, China and Europe.

As regards the credit of discovery of rose oil, history shows that the Arabs who were great alchemists and who developed the art of distillation, probably discovered the rose oil. Apparently, Avi Cena, the great discoverer, would have probably discovered the art of distillation in late nineth century. Whatever may be the historical truth, it is well established that rose perfume has been one of the most valued items of perfumery and flavour for thousands of years.

There are three species of roses which are used for commercial production of rose oil, concrete and absolute.

Rose

Rosa damascena Mill. var. 'Trignitiptala' Diek (pink damasc rose). This species is most common and gives the highest quality of oil. It is cultivated in Bulgaria, Turkey and India for production of rose oil. Oil of damasc rose also fetches the highest price. According to Darlington (1963), it is a hybrid between *Rosa gallica* L. and *Rosa moschata* Hook. (Fig. 1).

Rosa centifolia L. (light pink or cabbage rose). It is cultivated for production of essential oil as well as concrete and absolute in Southern France and Morocco. This variety yields inferior-grade oil and fetches a lesser price.

Rosa gallica L. Cultivated in South Russia. This variety also gives inferior-grade oil.

Although it is very difficult to give exact figures of rose oil production, it is estimated that about ten tonnes of rose oil is produced in the world today, of which Bulgaria produces more than five tonnes followed by Turkey, Morocco and the rest. India produces a very small quantity of rose oil which does not exceed more than 10 kg. Most of the Indian production of rose is converted into rose water. The actual estimate of production of rose oil in Russia is difficult to be made, as it does not enter the world market. However, as indicated during personal discussions 2-3 tonnes of rose oil is produced in Russia.

Most of the rose oil is obtained by steam distillation and cohobation using modern stills. Russians employ a combination of steam distillation and solvent extraction. However, quality of the product is poor.

Uptil recently most of the rose oil/rose water in India was produced in very primitive copper stills. However, recently the Central Institute

Fig. 1. *Rosa damascena.*

Fig. 2. *Jasminum grandiflorum.*

of Medicinal and Aromatic Plants has developed modern technology which is equivalent to Bulgarian technology and a semi-commercial plant has already been installed in Hasayan Block of Aligarh District.

A small amount of rose perfume is also produced in the form of rose concrete. In this process roses are treated with petroleum ether. *R. centifolia* is ideally suited for production of rose concrete. *R. centifolia* is cultivated in Southern France and Morocco.

The most important constituents of rose oil are: citronellol, nerol, geraniol, linalool, phenyl ethyl alcohol, farnesol, citral, eugenol and some minor constituents like damascone, rose oxide and rose furan. Rose oil is one of the main constituents of some of the most costliest and refined perfumes and cosmetics. In fact no high-grade perfume is possible without certain amount of rose oil or its constituents. It gives depth to the odour and also gives characteristic floral top notes to the perfumes. Certain amount of rose oil is also used in snuff and chewing tobacco, alcoholic drinks, etc. Rose water is extensively used in flavouring foods and confectionery.

Jasmine (*Jasminum grandiflorum* L.)

Jasmine has been one of the most delicate perfumes used since the beginning of human civilization. Next to rose, jasmine has been the most important perfumery raw material in modern perfumery industry (Fig. 2.)

Species of jasmine are probably indigenous to foot-hills of Himalayas.

Jasmine flowers have been used for religious purposes and making scented oils and *attars* or several thousand years. This plant was probably brought to North Africa by Arabs.

The word jasmine comes from Arabic word, 'Yasmine'. Although there are several species of Jasmine which have scented flowers and which are used in India for making garlands and *attars*, only one variety, viz. *Jasminum grandiflorum* L., called Spanish Jasmine, is employed for making modern jasmine perfume in the world today.

Another species of jasmine, *Jasminum sambac* (L.) Ait., often referred in India as *bela, motia* or *mogra*, is also employed for making oriental *attars* in India. However, it does not have any international market.

Oil of jasmine is so delicate that it cannot be steam-distilled and it is obtained in the form of concrete by solvent extraction. Jasmine concrete is produced in Egypt, Morocco, Algeria, France, Italy and India. Egypt is the major producer accounting for more than 10–15 tonnes concrete per year, followed by Morocco, Algeria, France, Italy and India.

Production of jasmine concrete started in India only recently and a limited amount is produced by two firms in Madras. The variety of jasmine used for processing in India is a strain of *Jasminum grandiflorum* which was introduced from France. The main constituents of jasmine concrete are: benzyl acetate, benzyl benzoate, geraniol, terpeniol, eugenol, benzaldehyde, nerol, indole, benzyl alcohol, jasmone, methylanthanilate and methyl jasmonate.

Jasmine perfume is used in most of the high-grade perfumes and cosmetics and no high-quality perfume can be made without certain amount of jasmine concrete or absolute.

Tuberose (*Polianthus tuberosa* L.)

Tuberose is native of central America. It is one of the most common sweetly scented ornamental plants, which grows in tropical and sub-tropical areas. Most of the tuberose is grown for ornamental purposes, for use as cut flowers. However, to a limited extent it is used for production of concrete and absolute in Southern France, Mexico, Morocco and India. Concrete is prepared by extraction of flowers with petroleum ether, which can be converted into tuberose absolute by alcohol washing. Only single-flower variety is preferred for production of concrete and absolute for perfumery purposes, as the double-flower variety is not suitable for extraction of concrete absolute, because of its lower essential oil content.

It is one of the most valuable and expensive perfumery raw materials obtained from flowers and used in very high-grade perfumes, specially to give a floral note with sweet aroma.

The most common constituents of tuberose concrete/absolute are geraniol,

nerol, benzyl alcohol, methyl benzoate, methyl salicylate, eugenol, benzyl benzoate and methyl anthranilate.

Carnation (*Dianthus caryophyllus* L.)

Next to rose and chrysanthemum, carnation flowers are the most commonly used and highly valued cut flowers used throughout the world. Most of the carnation flowers are grown in the world for ornamental purposes and find wide use in the cut flower industry.

However, carnation flower also has sweet aroma, which is used to a limited extent for extraction of concrete. Carnation perfume is extracted with petroleum ether in the form of concrete, which can be converted into absolute by alcohol washing. Its concrete content varies from 0.2 to 0.3%.

Carnation flower is cultivated to a limited extent for production of concrete absolute in France, Germany, Switzerland and Italy. It is used in high-class perfumes mostly to intensify notes of roses, lily and other floral notes. The main constituents of carnation flower are: eugenol, phenylethyl alcohol, benzyl benzoate, benzyl salicylate and methyl salicylate.

Champac (*Michelia champaca* L.)

Champac is a common ornamental tree having sweetly-scented flowers, grown in tropical and sub-tropical areas of the world. This tree is native to Philippines and is cultivated in Indonesia, India, South China and Re-Union Islands. Only a limited amount of flowers is used for production of concrete and absolute in China and Re-Union Islands. Total production of concrete and absolute is not more than 300 kg per year. It is used in high-class perfumes for giving a leafy floral note. It mixes well with rose and violet, etc. and concrete content ranges between 0.16 and 0.2%.

Honey-suckle (*Lochnera caprifolium*)

It is one of the most commonly grown, scented ornamental plants in temperate areas throughout the world, specially around the boundaries and gates of houses. However, flowers are also used for production of concrete to a limited extent. Flowers are extracted with petroleum ether for making concrete which can be converted into absolute by alcohol washing. This is used in perfumes for giving a fatty floral odour. It mixes well with jasmine and orange flavour and it is used in very high-class perfumes. Honey-suckle is cultivated for production of concrete to a limited extent in Southern France.

Hyacinth (*Hyacinthus orientalis* L.)

Hyacinth is one of the most commonly cultivated ornamental plants grown throughout the temperate areas. To a limited extent, it is cultivated in Holland for

production of concrete. It is used in high-class perfumes to give a sweet, green floral odour. However, the use of hyacinth concrete and absolute is only limited. The important constituents of hyacinth oil are: isoeugenol, benzyl alcohol, phenylethyl alcohol, benzaldehyde and cineol.

Orris root (*Iris* species)

Orris root is cultivated in the temperate areas of the world as an ornamental plant. However, rhizomes of *Iris germanica* and *I. pallida* are used for production of resinoids and perfumes. Iris perfume can be produced by steam distillation or obtained in the form of resinoid by solvent extraction. Orris root resinoids are used to a limited extent as perfumery raw material in France, Morocco, Italy, England and the USA. It is used in high-class perfumes and soaps and blends well with ionones of sandal wood, citronella and in tobacco type notes. The most important constituents are: caprylic acid, pelargonic acid, capric acid, tridecylic acid, benzoic acid, benzyl alcohol, linalool and geraniol.

In addition to above ornamental plants, other plants which are used only in minor quantities for production of essential oils and perfumes are as follows.

Plumeria (*P. alba* L. and *P. rubra* L.)

These flowers are extracted for production of concrete to a very limited extent in China and used in perfumes to give honey-suckle- and tuberose-type odour.

Sweet Pea (*Lathyrus odoratus* L.)

It is a common garden plant used for ornamental purposes. To a limited extent flowers are extracted for production of concrete in Southern France. It is used in perfumes to provide a floral note and it mixes well with honey-suckle, rose and hyacinth.

Narcissus (*N. poeticus* L.)

It is a common garden plant grown in the temperate areas of the world. To a limited extent flowers are extracted for production of concrete, which is used in high-class perfumes.

Gardenia (*G. florida* L.)

It is a common garden plant having sweet-smelling flowers. To a limited extent flowers are extracted for production of concrete and absolute, which are used in high-grade perfumes.

Magnolia (*M. grandiflora* L.)

Flowers of magnolia are used for production of concrete to a limited

extent, which is used in high-class perfumes.

Sweet violet (*Viola odorata* L.)

Violet flowers are used, to a limited extent for production of concrete which is used in high-grade perfumes.

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15

Hybrid Seed Production in Flowers

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DURING the World War II, in the early forties of the present century, when Japan was undergoing through a critical period, a silent but most significant revolutionary change occurred in floriculture. It was the exploitation of hybrid vigour in *Petunia* when the technique for producing all double F_1 hybrids was developed for the first time. This paved the way later for introducing numerous outstanding F_1 hybrids not only in *Petunia* but in many other types of flowers in several other countries like the USA, the Netherlands, Denmark, West Germany and the United Kingdom. Now F_1 hybrids are available in many flowers from A (*Antirrhinum*) to Z (*Zinnia*), including *Ageratum, Begonia, Calceolaria, Cyclamen,* carnation, *Dianthus, Geranium, Gerbera,* hollyhock, *Impatiens,* marigold, *Nicotiana, Petunia, Portulaca,* stocks and a few others.

Although the first F_1 hybrid in *Petunia* was produced in early 1940's it was only after about a decade that rapid advancement in development of F_1 hybrids in other flowers took place. There is a continuous creative search for new F_1 hybrid flowers. As a result of the immense popularity gained by the hybrid flowers, newer and more attractive hybrids are being released year after year by many seed companies in the world. A few important first hybrids in flowers are *Petunia* (1940–50), *Geranium* Single (1960), *Antirrhinum,* pansy, marigold, *Zinnia* (1965), *Ageratum* (1966), *Geranium* Double (1970), *Dianthus, Begonia, Impatiens, Portulaca* (1976–77), *Gerbera* (1980) and carnation (1981).

ADVANTAGES OF F_1 HYBRIDS

The main advantage in hybrids is the unique combination of appreciable vigour and uniformity. Generally these two characters are opposed to each other in open-pollinated varieties. When these varieties are selected for uniformity they lose their diverse genetic make-up which produces vigour. Besides having outstanding vigour, the F_1 hybrids if selected judiciously have

other advantages too, such as dwarf and compact plants, with basal branching, extremely free-blooming, early flowering, doubleness, larger flowers, longer duration of flowering, tolerance to heat and humidity and disease resistance. The hybrids of *Petunia, Dianthus, Impatiens, Begonia* and *Geranium* are dwarf and compact with basal branching. In most of the flowers the hybrids are very floriferous with large flowers and early blooming. *Geranium* hybrids raised from seeds are not likely to carry diseases transmitted by cuttings or slips as in standard geraniums. Faster growth and a longer growing season are the characteristics of hybrids in *Petunia* and *Geranium.* Doubleness in *Petunia* can only be produced successfully through hybrids. In stocks (Hansen's Double) by selecting the pale green-leaved seedlings and discarding dark-green foliage under cool conditions of growing, it is possible to grow 100% double-flowered plants. *Begonia* and *Gerbera* hybrids are tolerant to heat and humidity. The triploid hybrid Nugget, F_1 hybrid of the African marigold (*Tagetes erecta*) and the French marigold (*T. patula*), being sterile, the absence of fertilization and seed-set has the unique ability of holding the flowers fresh on the plant for a longer period. In the Butterfly hybrids of *Antirrhinum* the flower shape is unusual, each floret is like a colourful butterfly exposing more colour than the standard varieties.

HYBRID BREEDING TECHNIQUES

The F_1 hybrid breeding process, though very fascinating and rewarding, is long, costly and requires considerable skill. The breeding cycle is accelerated by growing the breeding material out-of season at any other suitable location. The process of developing inbred lines, making test crosses and testing the resulting F_1 hybrids are repeated several times to find a hybrid good enough to introduce. Hundreds or thousands of test crosses are made to find one new hybrid. The inbred lines come from the standard open-pollinated varieties or occasionally from the wild related species, which is a time-consuming procedure but brings out dramatic changes. New lines are developed from recombination of existing lines. It is necessary to search for new sources of breeding material for further improvement in hybrid varieties. The best plants from each inbred line are selected for test crosses. The promising inbred plants are crossed with a large number of plants from a different inbred line or lines. The F_1 hybrids produced from these test crosses are then grown and observed in extensive greenhouse and field trials. A few most promising F_1 hybrids are also tested in university or any other agricultural experiment station and seed company trial grounds at several locations, within and outside the country. The year before a new hybrid is released, hundreds of samples are distributed to commercial plant growers. This provides additional information on performance and cultural methods under

commercial conditions in each agro-climatic region.

There is a constant endeavour by flower breeders to produce new, more attractive and brightly-coloured hybrids. With the advancements made in new bedding plant technology in the USA such as automated systems, smaller containers, shorter crop time, energy stress and singulated seeding, hybrid varieties have been tailored to meet the requirements of commercial floriculture and consumer demands as in *Petunia*. For instance, *Petunia* hybrids have been bred for earliness in flowering, high, even and quick germination, seedling vigour in plugs or 'packs', compactness, ease of handling and response to growth retardants. However, improvement in these characters suited to bedding industry have been made without sacrificing the superior performance in the garden. This is ensured by testing the performance of a hybrid both in the pack and in the field. Only those hybrids which show good performance in both the tests are selected for further extensive trials.

MAINTAINING AND IMPROVING HYBRIDS

Once a new hybrid is produced, the work is not over. The parent lines must be maintained and retested to make sure some of the desirable attributes of the hybrid are not lost. The uniformity in hybrids depends upon the genetic purity of parental lines.

PRODUCTION OF F_1 HYBRID SEED

Most of the hybrid seed is produced by hand in greenhouse. Both emasculation and pollination are done by hand which enables the breeder to have a wider choice of parents for crossing. However, in flowers of family Compositae where emasculation and pollination by hand are difficult, like marigold and zinnia, male sterility is used for hybrid seed production. Collection of pollen with the help of a vacuum pump, dehiscence of anthers for pollen under ultraviolet lamp, storage of pollen at cool temperatures and use of pollen gun for pollination are some of the useful innovations facilitating hybrid-seed production. In many type of flowers like *Petunia, Antirrhinum* and *Nicotiana*, which have numerous small seeds in a capsule, a single pollination produces a large number of seeds. About 2,000 flowers of *Petunia* are needed to produce about 30 g of seed. Harvesting of seeds at proper ripening stage, cleaning and grading of seeds are essential processes before sale. At every stage of production care is taken to avoid selfing or natural cross-pollination or both to ensure complete hybridity and genetic purity. Harvesting, processing and storage of seeds are done carefully so that there is no mechanical mixture.

WORK DONE IN INDIA

Pronounced hybrid vigour has been reported in some flowers like marigold, *Antirrhinum*, balsam, hollyhock, *Petunia*, and a few others. These studies were carried out mainly at research institutes. Seed companies like the Indo-American Hybrid Seeds is engaged in commercial hybrid seed production in *Petunia, Antirrhinum, Geranium, Nicotiana,* marigold and *Gloxinia*. Besides selling the seeds in domestic markets F_1 seeds are being exported to countries abroad. Other seed companies and government agencies may also start production of F_1 hybrid seeds in future. In research institutes and agricultural universities, priority should be given to heterosis breeding as it is undoubtedly a most rewarding and profitable venture for both the floriculturists and seed producers. The hybrid-seed production being labour intensive has a great potential for employment of youths in rural and sub-urban areas. It may also generate gainful income by setting up of ancillary industries dealing with equipments and other facilities needed like greenhouse, small seed-processing machinery, seed packaging, etc.

16

Export Potentialities of Ornamental Plants and Cut-flowers from India

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THE offering and exchange of cut-flowers and their use in home decoration have become an integral part of living in human society. Besides their aesthetic importance, trees and other ornamentals planted in urban areas contribute to amelioration of the polluted environment. Among the various ornamentals, the cut-flowers have the biggest import-export trade in the world, followed by live plants, cut foliage, seeds, bulbs, tubers, corms, etc.

The total imports of ornamentals in Europe at present are approximately worth \$ 2323 million comprising mainly cut-flowers (\$ 1044 million), followed by cut foliage (\$ 143 million), bulbs, corms, etc. (\$ 325 million), and live plants (\$ 811 million). During a five-year period the floriculture trade increased from \$ 1278 million in 1976 to \$ 2323 million in 1981, recording a growth rate of about 82%. In the world trade of ornamentals, the share of developed countries is 91% whereas developing countries contribute only 9%. Among the exporters, the Netherlands is the largest (64.3 %) in all items except cut foliage, for which Italy is the biggest exporter. The annual consumption of cut-flowers in the world is worth about \$ 13 billion. The Federal Republic of Germany is the biggest consumer and importer of cut-flowers. The demand of cut-flowers is increasing in the developed countries. The per-capita consumption of flowers in the Federal Republic of Germany has increased at the rate of 10% every year during the last decade. In the European markets cut f owers are regularly imported to supplement the internal production. For instance in the FRG the annual internal production worth about DM 1000 million is sufficient to meet only 42% of its demand and the rest 58% requirement is met from the imports, mainly from Holland, France, Italy, Israel and South Africa. The import of cut flowers in European markets is maximum during winter months (November to April) when there is a shortage and the prices are at least 50% higher than in other months.

Several developing countries of the tropical region, where the climate is

warm during winter, therefore, have started exporting cut flowers to European countries. The important exporting countries from developing region are Israel, Columbia, Brazil, Kenya, Ivory Coast, Thailand, Sri Lanka, Singapore and South Africa. Israel is the leading exporter of cut flowers, particularly rose and gladiolus, to Europe, having a share of about 11% followed by Columbia (5.3%), Thailand (2.7%) and Kenya (1.3%). There is a large-scale export of orchids from Thailand, Sri Lanka and Singapore; rose, carnation and gladiolus from Kenya; rose, chrysanthemum and carnation from Columbia and Brazil; and rose, *Protea* and gladiolus from South Africa.

EXPORT FROM INDIA

The pioneering efforts of the floriculturists of the Indian Agricultural Research Institute, New Delhi in collaboration with the State Trading Corporation of India, in successfully exporting cut roses to Paris, Rotterdam and Frankfurt in 1969, paved the way to develop export trade of floriculture materials. Unfortunately during the last 15 years there has not been any significant advancement in the export trade of ornamentals from India, despite the fact that the country has varied and suitable climate, low cost of labour and progressive farming technology. The export of floriculture items from India were Rs 2.4 million in 1976–77 which increased to Rs 8.4 million in 1980–81 but declined to Rs 6 million in 1981–82. Almost half of the exported quantity comprised foliage and flowering plants (48%), followed by cut-flowers (38%) and other items (14%). The cut flowers were sent mainly to the FRG, Holland, Italy (31%) and the USA (19%) whereas live plants were exported to Gulf countries (UAE and Oman).

In view of the immense potential for export of ornamentals from the country recently the Government of India and its other agencies like the Ministry of Commerce, Processed Foods Export Promotion Council (now APEDA), State Trading Corporation and Trade Development Authority have given encouragement and support to it. In the past there had been a few seminars and meetings to discuss the various problems of export trade of floriculture materials and to have useful interactions between different organisations concerned with export trade. A trade delegation of growers, trade and marketing organized by the Processed Foods Export Promotion Council (Ministry of Commerce) visited Moscow, Amsterdam, Hamburg and Frankfurt to study the various aspects of production and marketing of flowers and live plants for export and submitted a report along with recommendations to the Government of India.

CONSTRAINTS IN EXPORT

There are several constraints in export trade of ornamentals from India at

production, transport and marketing levels which have been identified by various agencies. These include poor production, both from the points of view of quantity and quality, lack of planting material, high commodity, air freight rate, inadequate incentives and financial assistance for export and absence of organized marketing channels and monitoring system. Commercial floriculture is a recent development in this country. Although almost all kinds of flowers and ornamental plants are grown, there is no specific information on the level of existing production in terms of area and production under floriculture crops in India. Such information is useful in planning for increased production for export. The importing countries have demands mainly for cut roses, chrysanthemum, carnation, gladiolus, and some exotic flowers like orchids, anthurium, heliconia, protea etc. Besides, there is a market preference for specific varieties and high quality with standard specifications. However, in India large quantities of planting material of export varieties of most of the flowers are not available. There are rapid and continuous developments abroad in evolving better varieties of flowers and other ornamental plants specifically for export markets. The export-oriented varieties of flowers are rather short-lived and these are frequently replaced with newer and better ones.

With the existing meagre facilities of infrastructure for floriculture research available in government research institutes and agricultural universities as well as in private nurseries and seed companies in India, it may not be possible to evolve varieties suitable for export as expeditiously as some of the leading exporting countries. It is therefore advisable to introduce the important export varieties of flowers for rapid multiplication and production in the country for export trade. However, simultaneously efforts should be made by floriculturists to develop Indian varieties which may be suitable for export.

In the markets abroad cut flowers of high quality only are acceptable. The inferior quality flowers are rejected and destroyed in some of the large flower auction markets like Aalsmeer in the Netherlands. The cut flowers produced in our country generally do not conform to the international quality specifications. In roses only the flowers grown under glass-houses are in damand in the European countries.

Packaging of cut-flowers and live plants for export which is specific for each kind of flower and plant is not fully developed in our country. Besides, proper type of packaging material, which is corrugated cardboard boxes in most cases, similar to those used abroad, is also not available. Packaging should be functional, economical and attractive besides being acceptable in foreign market.

The cut flowers and live plants which are highly perishable are transported by air, invariably by direct flights without any transhipment to distant markets abroad. Cut flowers are also given cold treatment before packing them. The packed cartons are transported to airport in air-conditioned vans and kept in cool

place before loading in the aircraft. Such facilities do not exist here at present.

Flowers and live plants are not grown in large areas in the country. Hence, small growers of flowers for export may require assistance in marketing their produce. Since the importing countries generally have demands for very large quantities of cut-flowers, it may not be possible for any individual grower to meet these export requirements. Also the average area available with the grower near international airport is not large, being about 0.4 ha to 2 ha or so. It may, therefore, be necessary to make arrangements for collection of flowers from several small growers through either a consortium or federation of growers or by any export house. Export houses and big industrial organisations in Kenya and Sri Lanka have developed export trade of cut-flowers. Similarly orchid cooperatives of about 500 members each have been organised in Bangkok for export of orchids. Each member grower grows orchids in about 2–4 hectares and delivers each morning cut-flowers. to the co-operative. These are sorted, graded and packed for export.

Recently the Government of India and other agencies, like the Ministry of Commerce, Processed Foods Export Promotion Council, State Trading Corporation and Trade Development Authority of India have paid greater attention to export of ornamentals and have provided incentives to this new enterprise. Cut flowers have been included in the select list of products and the exporters of cut flowers are given the same benefits as allowed to other exporters. They are allowed to import packing material, peat, seeds and bulbs and plant material, fertilizers etc. against export of live plants. Similarly special commodity air freight rates for export of flowers and live plants have been allowed by Air India from Delhi or Bombay to a few selected destinations on some sectors.

SUGGESTIONS FOR PROMOTION OF EXPORT OF ORNAMENTALS

1. It is necessary to have specific information on the present level of production, area and locations of flowers and ornamental plants in the country. Such information will be useful in planning production for export and in making projections for export of floriculture items.

2. The flowers and plants that are in demand abroad and can be easily produced in the country either in open or in greenhouse, glass-house or plastic house under controlled environment may be identified. It may be worthwhile to concentrate efforts on orchid, rose, carnation and chrysanthemum. Rose will have to be grown either in greenhouse or glass-house or under partial plastic cover. Since glass-house technology and production is almost unknown in the country, it is suggested that the Government of India may allow import of 2 or 3 units of climate-controlled glass-house from abroad without any duty. These may be used

for pilot trials of production for export and also serve as a prototype for fabrication here.

3. Flowers are highly perishable, and in the beginning there may be rejection of consignments of inferior quality or those damaged during transportation. Hence the projets of flowers and live plants with 50% quantum of production for export may be given the same benefits as those for 100% export-oriented projects.

4. It is suggested that the air freight to destinations in Europe may be reduced from the current rate to make it more competitive and thus encourage exporters to send flowers and live plants to European countries. Foliage plants of excellent quality can be exported from Bangalore and Pune to European markets at competitive price if there is a reduction in air-freight.

5. Since floriculture industry is capital intensive, provision of bank loan on a lower rate of interest (about 6%) may assist many floriculturists to take up production of flowers and plants for export.

6. Small growers of flowers and live plants for export may require assistance in marketing their products. The marketing and development of trade may be undertaken by the State Trading Corporation, Processed Foods Export Promotion Council and Trade Development Authority of India. Collection of flowers and live plants from small growers may be arranged through a consortium or federation of growers or by any export house. They can also assist in market surveys and marketing intelligence for the guidance of growers and exporters. Export houses and big industrial organisations may be induced to enter into the export trade of floriculture items, like those in other developing countries such as Kenya and Sri Lanka.

7. Research on flower crops for export should be intensified so that it may assist in establishing and promoting export trade of ornamentals. Sustained efforts must be made on introduction of popular export varieties from abroad and rapid multiplication of plant material using latest techniques of tissue culture. Studies may be undertaken on pre- and post-harvest physiology and technology, packaging and control of diseases and insect pests of cut flowers and live plants with a view to producing internationally acceptable quality products. The research units may also help in testing of newly introduced plant materials required for export. Regular interactions between research workers and floriculturists engaged in export will be beneficial in the development of export trade. Such research units may receive financial assistance from the central and state governments as well as from export houses.

Presently a few research organisations are engaged in export-oriented projects, like the Indian Institute of Horticultural Research, Bangalore; Indian Agricultural Research Institute, New Delhi; Punjab Agricultural University, Ludhiana; the National Botanical Research Institute, Lucknow, Uttar Pradesh;

and the All-India Co-ordinated Floriculture Improvement Project of the Indian Council of Agricultural Research at several locations in the country. The Council of Scientific and Industrial Research at the CSIR Complex, Palampur (Himachal Pradesh) is also initiating research on floriculture items for export.

8. There is an acute shortage of qualified and trained staff in floriculture, especially those having experience of growing flowers and live plants for export. The Central and State Governments and agricultural universities may consider deputing floriculture staff for training abroad for this purpose.

17

The Japanese Garden

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THE Japanese are a warrior race, who are fierce in combat but gentle in the arts of peace. Like most warrior races, they have intense love for nature and poetry. Their love of nature is born of the landscape of Japan, with its green cascaded hills, its pine-girt shores, and purity of its silver air. A lush dark-green vegetation clothes the shores of the sea bays, and the trembling bamboos with their feathery leaves stand out from among the pines conspicuously. In the bamboo groves, learned men retire to discuss philosophy and the mysteries of life. Fujiyama, the peak of the white lotus, the changeless home of peace, dominates life by its silent beauty. In the mist, the pine trees with their twisted branches loom like ghosts in the horizon. The volcanic rocks and mountains have a characteristic look and appear very ancient. The rice fields appear like a mosaic of mirrors during the planting season when they are flooded with water. The farmers wearing grass cloaks and umbrella-like straw hats transplanting paddy give a quaint appearance to the countryside. The thatched houses of the farmers harmonise with the landscape, and the beautiful temple bells vibrate the music of love and repose.

Japanese poetry abounds in the intense adoration of nature, the worship of great rivers, delight in clouds and lake-mists and in the flight of wild geese. In it one hears the voice of the ocean, the music of the pattering rain, and the roar of the water-falls. As Okakura says, "It is through Toenmei and other poets of the South that the purity of the 'dew-drooping' chrysanthemum, the delicate grace of the swaying bamboo, the unconscious fragrance of plum flowers floating on the twilight water, the green serenity of the pine, whispering its silent woes to the wind, and the divine narcissus, hiding its noble soul in deep ravines, or seeking for spring in a glimpse of heaven, become themes of poetic inspiration, which, when blended with Buddhist ideals in the great liberalizing Tang period, bursts forth again in the Sung poets, who are, like Toenmei, a product of the Yang-tse mind, everseeking the expression of the soul in Nature",.

The Japanese is a great lover of plants and flowers. And in fact no nation has such deep passion for flowers as the Japanese. The princesses loiter with the peasant girls in their pleasure gardens without pride or vanity or any class distinction, all equally self-inebriated, a sight which fills the human heart with rare gladness. Speaking of offering flowers to the Buddha, in one of her poems, Empress Komio says, "If I pluck them, the touch of my hand will defile, therefore standing in the meadows as they are I offer these wind-blown flowers to the Buddhas of the past, the present and the future". This simple poem indicates the love and reverence, the Japanese people have for flowers, and it is no wonder that they created gardens of such subtle beauty and charm. If cultural development of a country is judged from its gardens, Japan no doubt, occupies a place at the apex of the cultural pyramid.

Strange as it may seem the Japanese garden, the most beautiful and highly developed of all the present-day gardens, in whose praise westerners have written so much, has its roots in the Indian soil. India, the mother of thought, has very close cultural links with China and Japan. It was through the mountain passes of the North-West that India poured her intellectual torrents upon the Far-Eastern world. A lively communication was maintained between India and China through these passes, and travellers, pilgrims and traders carried Indian art and religion to China. India, from sixth to seventh century A.D., was the centre of the Buddhist universe, and Indian monks carried the message of the Buddha to the Far East. From China, Hindu ideas reached the remote island of Japan. There may have been earlier contacts between the two countries, as the Japanese have traditions of solar descent and a number of Hindu Gods have found place in the Japanese pantheon. The Buddhist saints from India were the torch-bearers of culture and progress, who adventured into Central Asia, and China, carrying the message of the Buddha and also the idea of the temple-garden. Describing the history of gardening in the Far-East, Mrs. Villiers Stuart writes, "The Indian Buddhist garden, forgotten in the land of its origin, still survives further East, although so transformed and tinged by the genius of another climate and another people, that the garden history of the plum and cherry trees, the wistaria and the morning glory, the lotus and the Japanese iris, is often misunderstood and overlooked. For all that, the Japanese garden, the most intimate and charming expression of Japanese nationality, came like so many of their arts, from India through China and Korea. And from the early temple gardens made by the Buddhist monks and pilgrims, the whole beautiful and elaborate system of Japanese garden craft has gradually been built up. The Indian Lotus-bearers reached China both through Turkistan and by the Southern route through Burma and

Cambodia, and 'Coal Hill', near Tatar city in Peking, is a relic of the Pleasure Hill idea. The style is supposed to have been introduced into Japan in the sixth century by one, Yohan Loan Han, who constructed great mounds, some of them a hundred feet high or more, and brought water in conduits to form lakes and ponds. These hills and rockeries were planted after the Indian fashion with flowering trees and shrubs."

The Budhist temple garden flourished in the soil of China and Japan. In the moist temperate climate of Japan so favourable to the growth of vegetation, and in the hands of an artistic people, it evolved till it was transformed into almost a new type of garden. The native genius of the people asserted itself and the Buddhist temple garden developed into the Japanese landscape garden.

The modern Japanese garden is the result of the efforts of priests and garden-lovers of Japan spread over a period of eleven centuries. It aims at providing in miniature the composition of a mountain-side landscape with a characteristic cascade, a small lake with an island, a bridge, characteristically arranged stones and rocks, and ornamental stone-lanterns suggesting light. Garden designing was made a part of the ritual of their religion by the priests of Zen sect of Buddhism, and the gardens designed by the Zen priest Muso Kokushi in the early part of the fourteenth century are preserved in Kyoto even now. Where water-supply is deficient, dried-up rock gardens are in vogue and sand is strewn to suggest water. There is no massing of trees and a solitary cherry tree planted at a suitable angle against the background of evergreen trees appears far more beautiful by contrast than clumps or avenues. Simplicity is the keynote of such gardens. So far as possible trees are planted in an environment approximating their natural habitat.

However, it would be erroneous to run away with the idea that a Japanese garden consists of a few stones, bridges and stone-lanterns. The basic conception of Japanese garden is calm and peace. It is a place where you come for meditation, a place where you retire to forget the worries of the world, and the hurry and bustle of modern life. As Mrs Basil Taylour so rightly observes, "The key to understanding of the difficult, highly involved art of Japanese garden-making is spiritual. It is an art which has for its conscious or unconscious aim the refreshment of the body by raising the mind to another plane of feeling."

You are not expected to hurry through a Japanese garden. The bridges, the stepping stones and rocks are so placed that you simply cannot rush through. The rustic shelters in the shade, the tea houses, the gold-fish in the pool, the soothing patter of water from the water-fall all tempt you to linger on. You admire the delicate rosy blossoms of cherry trees, and you open your heart to the beauty of white plum blossoms which display their lovely flowers against a background of

deep green furnished by conifers, like cryptomerias and firs. Guarding the gate of the garden are two venerable pine trees symbolic of long life. Crimson-red azaleas lie bleeding on the rocks among the pine-needles. "If there were ever a flower that personified colour then it is surely the azalea. It is the rainbow of flowers, and there seems scarcely a shade of colour not to be found in its blossoms. To look at the azaleas is to look into the very paint-box of Nature itself." Irises display their beautiful flowers, proud of their glamour as they see their reflection in the limpid water of the pool. From your seat you watch the flight of birds, and contemplate the beauty of delicate camelias and peonies. Delicately coloured flowers follow each other in succession from month to month, and all the year round, there is something to love and admire. Flowering trees are irregularly placed in happily chosen spots to give the impression of natural landscape. Practically all gardens in Japan are landscape gardens and are reproductions on a small scale of the scenery of Japan.

Water is the life of a garden, Moghul or Japanese. Describing the use made by the Japanese of water, apart from irrigation in their gardens, Mrs. Basil Taylour writes, "The rocks and stones are the bones of the skeleton, the contour of the land represents its features, the flowers and trees are the flesh and the adornments of dress, but the water is the life and soul of the garden. No one knows better than the Japanese landscape artist what compound interest in beauty he reaps by the repetition and reflection of his earthly garden in his watery one. Just as mirrors enlarge little rooms, as the sea beneath a sunset intensifies the glory of the western sky, so water in a garden doubles the interest, the beauty, and apparent size of the place in which it is put."

Pine trees which are great favourites of the Japanese are trained into artistic forms, and lean over the surface of the water in an attractive manner. Sometimes trees are trained into fantastic shapes like sailing boats. Palm trees are grown near houses to enjoy the music of pattering rain drops on their broad waxy leaves. In winter these tropical palm trees are protected by covering them with close-fitting jackets of rice-straw. Great attention is paid to the welfare of the trees, and when fruits are not edible, they are plucked off at an early stage to prevent a drain on the vitality of the tree.

The art of dwarfing and transplanting has considerably developed in Japan. There are trees scores of years old which look no bigger than saplings 2–3 years old.

Bonsai, the art of cultivation of dwarf trees has considerable vogue in Japan. Trees are dwarfed by growing in pots and mollusc shells and cutting their roots and they are trained to assume the shape of old trees. Thus the townsman can enjoy the beauty and feel the grandeur of ancient trees in the house, and he can create the atmosphere of the forest in his urban home.

Deciduous trees like cherries are transplanted even when as old as 30 years. When they are in a dormant condition and leaves have fallen they are dug out, the branches are pruned and the trees with as much soil clinging to the roots as possible are transported on huge carts to their new homes and planted. It is not uncommon sight in the cities of Japan to see people transporting their favourite trees along with their other belongings when changing houses.

As in the Moghul garden-craft, we find rich symbolism in Japanese gardening. The white blossoms of the plum are symbolic of spiritual beauty, while the pink cherry blossoms signify bodily or sensuous beauty. The plum has inspired beautiful poems of sadness and war. In the white flowers of the plum, the Japanese sees the heart of a soldier, who has learnt the secret of Nirvana. A Japanese women's beauty is frequently associated with the cherry-blossom, while her virtue is compared with the flower of the plum. The poet Motoori wrote: "If one should ask you concerning the heart of a true Japanese, point to the wild cherry flower glowing in the sun." 'Saki' is drunk when viewing cherry blossoms, for wine, women and cherry blossoms go together. Cherry blossoms have been popular for centuries in Japan, and Shogun Yoshimura loved this beautiful plant so intensely that he planted ten thousand cherry trees, along the banks of Tamagawa, so that the purity of the flowers may keep water of this river pure, thus safe-guarding the health of the inhabitants of Tokyo. Peach is the favourite of little girls who use its flowers in their festivals. Hideyoshi made his palace on a mountain which was planted with so many peaches, that it was called, "Peach Mountain".

Which one is prettier, the cherry or the plum blossom? It is said that one day Kinto Fujiwara, Great Adviser of State, disputed with the Minister of Uji which was the fairest of spring and autumn flowers. Said the Minister: 'The cherry is surely best among the flowers of spring, the *Chrysanthemum* among those of autumn.' Then Kinto said, "How can the cherry blossom be the best? You have forgotten the plum". Their dispute came at length to be confined to the superiority of the cherry and the plum, and of other flowers little notice was taken. At length Kinto, not wishing to offend the Minister, did not argue so vehemently as before, but said, "well, have it so; the cherry may be the prettier of the two; but when once you have seen the plum-blossom in the snow at the dawn of a spring morning, you will no longer forget its beauty".

The Chrysanthemum with the Plum, the Orchid, and the Bamboo constitutes the "Four Floral Gentlemen". With its numerous petals which appear like sun-rays, chrysanthemum signifies the rising sun, the symbol of Japan.

The conifers like firs, pines, and cryptomerias signify long life and

devotion, and are planted near temples. All these conifers are regarded as sacred, and are planted in avenues and clumps in the vicinity of the Buddhist and Shinto temples.

Festivals are celebrated in different months when the favourite flowers are at the height of their beauty. In the middle of April, when cherry blossoms are at their best the cherry-viewing festival is held. In November, when chrysanthemums are in their full glory, a festival is celebrated in honour of these flowers.

Thousands of Japanese visit the shrine of the God Tenjin in Kameido in February to enjoy the sight of the white blossoms of the plum trees. Hundreds of couples sip tea on benches placed under the ancient trees. At dusk, spherical paper lanterns swaying from the branches are lighted, and the white blossoms appear colourful under the reflected light of these multi-coloured lanterns. Poets write poems in praise of the plum blossoms on a special paper *Tanzaku* and they tie these oblong strips to the branches. Thousands gather at Kameido to admire the drooping purple flowers of wistarias in May. There are many places in Tokyo which are famous for cherry blossoms, particularly Mukojima, Arakawa, Uyeno, Asukusa Hill and the parks of Hikawa and Shiba. In early April, these places are crowded with visitors who come to admire the cherry blossoms and stay from dawn till late in the night. Old cherry trees are given special names and are mentioned with affection. Admirers of cherry blossoms carry flowers in the button-holes of their coats, drink beer and make merry round the flower-laden cherry trees glowing with electric lights. Giving his impressions of flower shows and festivals, Puran Singh writes, "The flower shows are as soft revelations of the Japanese soul, art and religion as the early dawn is of the mystery of creation. They infused an unutterable spirit of true religion into me. Judging by the way in which festivals are held in Japan, round the innocent saints—the flowers, it seems the Japanese nation as a whole is immersed in deep prayer. Every blossoming cherry tree is a Buddhist temple in Japan. There are national holidays to honour the arrival of the cherry-blossom. The whole people are literally drunk with the joy of the cherry. At the great fairs in Uyeno Park and the cherry dances of Geishas in romantic Kyoto, the genius of great Japan can be seen at its best and truest, and truly adored."

The morning glory with its transient beauty typifies all that is loving and beautiful in life. Recounting his experiences in Japan, Puran Singh thus describes the pleasure a Japanese family receives on watching the opening of buds of the morning glory. "A Japanese family sat round a flower pot that had three buds of the morning glory just opening their soul to the morning ray. It was as if the message came from Heaven to the travellers who had strayed to earth from there. So thankful was the reception by

the buds of that love-letter of Heaven. And as the morning glories began opening in the joy of that realised Nirvana, the mouths of the Japanese daughter, her father and mother began opening. It took about half an hour for the bud to blossom to fullness and by that time four Japanese mouths were fully opened and all the eyes too were red with the melting of the ray in those pools of wonder. It was religion, not merely an aesthetic pleasure. Verily, verily no nation of the East or of the West has merged itself so completely with the spirit of gods that is manifested on earth in the fatal innocence of flowers."

"Flower stories are endless," says Okakura in his book of *Tea*. "In the sixteenth century the morning glory was yet a rare plant with us. Rikiu had an entire garden planted with it which he cultivated with assiduous care. The fame of his convolvuli reached the ear of the Taiko, and he expressed a desire to see them, in consequence of which Rikiu invited him to a morning tea at his house. On the appointed day the Taiko walked through the garden but nowhere could he see a vestige of the convolvulus. The ground had been levelled and strewn with fine pebbles and sand. With sullen anger the despot entered the tea room, but a sight awaited him there which completely restored his humour. On the *tokehname*, in a rare bronze of *Sung* workmanship lay a single morning glory—the queen of the whole garden. In such instances we see the full significance of the Flower Sacrifice. Perhaps the flowers appreciate the full significance of it. They are not cowards like men. Some flowers glory in death, certainly the Japanese cherry blossoms do, as they freely surrender themselves to the winds. Any one who has stood before the fragrant avalanche at Yoshino or Arishyama must have realised this. For a moment they hover like bejewelled clouds, and dance above the crystal streams, when as they sail away on the laughing waters, they seem to say: "Farewell, O Spring, we are on to eternity."

This expresses the whole spirit of the Japanese race in a tragic story of the cherry and the morning glory.

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My 'Lumpyngnad' Garden in Shillong

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"BEWARE of Gardening" – says my family, as my passionate fondness for it is a hindrance to their participation in it. When I entered my house 'Lumpyngnad'* (which literally means "a pleasant hill") in Shillong, I was excited and commented, "I should check myself or otherwise this Garden will overpower me." Alas! I just lost my heart to it and immersed myself in it. It was diamond and gold, silver and copper, ruby and jade all combined producing constantly changing patterns of rainbows.

'Lumpyngnad' has age-old magnificent, graceful trees—some tall, some short, some erect and some spread all over, some filtering light and the others preventing it, some with flowers and some without. But each one with a personality. One pine tree (*Pinus khasiana*) facing our main lawn and the living room was our most favourite. It has the most unique formation—weather-beaten and all curved and yet so graceful. A creeper *Vitis* in winter showed its crimson glory resting on it and the golden morning light peeping through its branches uplifted our hearts. A look at it and the day was made.

And then there was a tall tree *Cupressus*. One evening when all lights suddenly went out, it seemed under the starlight to have grown like the "Jack and the beanstalk". Then only we realized how stately the tree was.

When the life stirred with the distant call of the spring, the birch (*Betula alnoides*) showed its tiny off-yellow leaves against the heavenly blue sky. Oh! it was breath-taking.

The fussy little *Acacia podalyriaefolia* was a constant delight— in or out of bloom. Its delicate grey-green, almost silvery grey, foliage was always attractive. But with the silvery leaves combined with tiny globular fragrant canary yellow flowers in masses, I was transported to heaven! And could easily say "if there is a heaven, it is here, it is here, it is here."

There was a wild peach tree. Its fruit was small, a little bitter and not too

*'Lumpyngnad' was the residence of the author during 1983–85.

palatable. But it gave clear rose pink flowers when no other tree was in bloom. It made a picture against the frame of clear blue winter sky speckled with clouds. It was a favourite of the bulbuls. But the most favourite of the bulbuls was the Bird Cherry which displayed its full glitter in November-December only for a fortnight but showed the real wealth of countless berries a month or so later. It was a happy time when hundreds of bulbuls perched on its branches, frolicked and fluttered, courted and played and filled the garden with their varying sweet notes. It was abundant joy and gaiety.

The four camellias together in a row with rosy pink flowers and glistening dark green foliage looked like sentinels of peace and harmony. The eyes just rested on them and got soothened. The anxiety vanished.

The mimosas (*Acacia decurrens*). Oh! the delicately fragrant ones—it was heartbreaking when their bloom faded. They brought freshness and joy and spring wealth.

The young *Magnolia grandiflora* hardly had a couple of flowers, but it spoke always, "I am the one who will reign here ultimately." I paid obeisance to it.

The oldest *kaiphal* tree (*Myrica esculenta*) was hollow from within and nested two colonies of bees. It was too risky to be too close to it. But it fed us with luscious sour-sweet berries for almost three months. Rose petals are showered on the royal ones and berries on the lesser mortals.

The weeping willow (*Salix babylonica*) was just beginning to weep. It had yet to learn much. I had to shift it down below as I was afraid of its too much weeping later.

There were many jacarandas but they were crowded over and never could show their sombre beauty. *Ligustrum robustum* was an excellent host for the orchids. But it was hollow with some pest attack and had to be chopped off. It fell down near the bee box, which had to be shifted and what an attack we had to face from them. We had respite only after the bee box was hastily replaced in its original position.

The deodar presented a very beautiful branch during a thunder storm. When the freshly dried white *Dombeya* flowers which had turned golden-brown were tucked on it and it was placed in a corner. It looked like the plumage of a peacock in dance.

The pomegranate with its scarlet blossom and yellow-green leaves with a tinge of bronze, located near the water tub for the birds, was always striking with its changing mosaic of hues.

The palm (*Livistona*) gave its dry leaves with long stalks. The joint-ends of these turned upside down looked like snake heads. A V-shaped pine branch turned upside down together with these stems gave an exotic look to the spacious dining room. It looked as if the snakes were also demanding their share.

The rhododendrons, more than 100 years old, were initially reluctant to show

their full glory. They were the most favourite hosts of the orchids. I talked to them constantly and chee·ed them up. They were fed with more than 100 kg of leaf mould spread over a circumference of almost 10 metres radius and filled with gallons of water. The blooms they gave– rich, red and shining and edible too. A picture of glory!

The transfer of trees from one place to another was celebrated almost like a change of house. The mobility of trees was very good provided they were handled with care. May was found to be one of the best months when light drizzle almost constantly kept the foliage moist. I owe an apology to two plants I lost in such a transfer. One was because there was water-logging below and the other—well, it just refused to respond to the change.

The deep mauve bougainvillea had gone up on a *Cupressus* to 25–30 metres high and its brilliance in June inspired me to plant bougainvilleas around all the tall trees at a distance from the house. *Toona ciliata*, a graceful tree 30–40 metres high, hosted one of the showiest ferns.

There were many more patient and dependable friends. There were innumerable younger and smaller ones—some demanding and some resisting. But I made friends with all of them over 3 months and thereafter it was easy sailing. They got many friends from the wild and they together had individual and mixed corners.

In this beautiful world of my own, I could spend nearly two years—walking, talking, rain-soaked, winter-chilled, thorn-torn, glass-cut. But I felt rich and warm. I share this joy today with Dr B.P. Pal, who in his gentle and quiet manner led me to the world of excellence in flowers and trees. His paintings, photographs and drawings all constantly inspired me for more than three years when I closely worked under him in the ICAR. Dr Pal is undoubtedly the doyen of modern horticulture in India and I was fortunate to receive from him guidance and inspiration. As Dr Pal turns eighty, I dedicate these thoughts to him. May many such small or big friends pave his way with beauty, joy and harmony.

Floriculture today is a recognised scientific discipline and a growing industry. Many Indian botanists have made contributions in this field during the last one hundred years but the credit for its present status goes to Dr B.P. Pal, the doyen of ornamental horticulture. His contributions have been outstanding and many and today his name is almost synonymous with ornamental horticulture.

This volume, which is dedicated to Dr B.P. Pal on his 80th birthday, contains articles on all facets of Ornamental Horticulture by leading floriculturists in the country. Some of the important subjects covered are: Floriculture Research, Rose, Chrysanthemum, Dahlia, Gladiolus, Bougainvillea, Jasmine, Orchids, Bonsai Culture, Essential Oils from Ornamentals, Hybrid Seed Production in Flowers, and Export of Ornamental Plants.

The lovers of Ornamental Horticulture will find this volume informative and interesting.

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